FEBRUARY 3, 1958 PRICE 50 CENTS

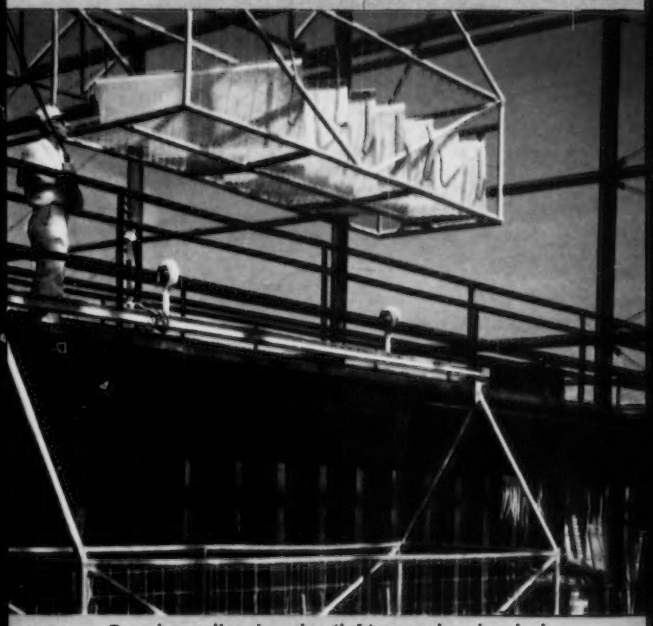
Product Engineering

McGRAW-HILL MAGAZINE OF DESIGN
RESEARCH AND DEVELOPMENT

DESIGN edition

Data Program on Reinforced Plastics

High-temperature Bearings



Templet coding in color (left) precedes chemical milling of seven depths, two tapers—*see page 5*

Now you can get standard sizes in C/R End Face Seals!

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BLUEMODEL AIR OPERATED TIMED IN
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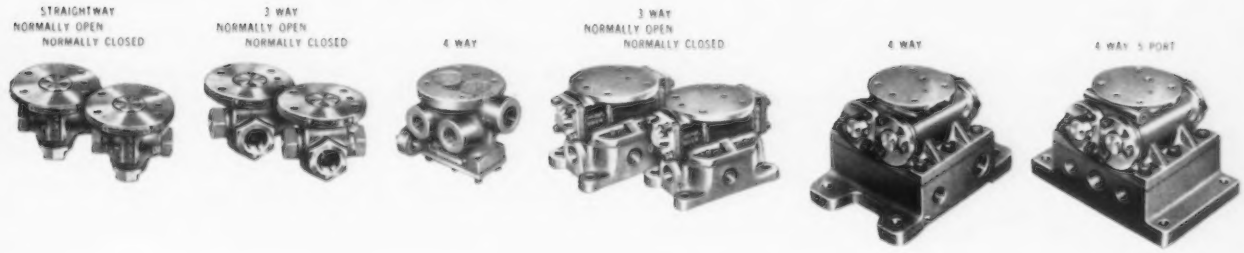
STRAIGHTWAY NORMALLY OPEN NORMALLY CLOSED
3 WAY NORMALLY OPEN NORMALLY CLOSED
4 WAY
3 WAY NORMALLY OPEN NORMALLY CLOSED
4 WAY
4 WAY 5 PORT

Now there are 11 heads and nine bodies to meet both usual and unique problems in the line which was designed to give you the longest life and greatest adaptability of any valve line in the world. All heads are readily interchangeable with all Skyline valve bodies, and the new Double-Stroke momentary adapter further multiplies the number of valve combinations. What is your problem? Drop us a note explaining it, or call your nearby Ross field service engineer for details on the Skyline valve to solve it.

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Ross OPERATING VALVE COMPANY

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Drilling mud, containing sand and rock particles, looks like this as it flows from a well hole. It is "freshened up" for re-use in a cleaning machine equipped with a wear-resisting Monel alloy screen. *Photo courtesy Standard Oil Company, (New Jersey).*

It's murder on most metals

when mud goes to the cleaners

The idea of putting mud through a cleaning process may seem fantastic. But that's exactly what they do in the oilfields.

Drillers use special chemically treated mud to cool high-speed bits, and to bring up loose sand and rock particles.

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Monel alloy has the strength and toughness needed to resist this wear and abrasion. It also withstands corrosion by the chemicals in the mud, and the acid used in cleaning the machine. It's the kind of metal that takes problem jobs in stride.

Do you have a problem job, too? Write for a copy of "Standard Alloys." Contains answers to problems of corrosion, abrasion, high temperatures, fatigue.

*Registered trademark

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Product Engineering

THE McGRAW-HILL MAGAZINE OF DESIGN, RESEARCH AND DEVELOPMENT

FEBRUARY 3, 1958 Vol. 29, No. 5

Chemical Milling— 50... C. H. Lundquist, U. S. Chemical Milling Corp.
Spurred by needs of aircraft designers, high-speed etching now gives big-scale production of parts that other shaping methods can't handle easily. Here's first design data.

New NEMA Standards for Motors— 54... R. Y. Newton, General Electric
Redesign has given reduced-size motors with same power. This article reviews the reratings for motors from 40 to 125 hp.

When Pistons Need Brakes— 56... Louis Dodge
That damaging bang should be taken out of end-of-stroke forces. Successful braking, reversing methods are described.

Making Instruments Readable— 61... R. M. Rowell, General Electric
The way they are lighted determines how fast and accurately they can be read. Here are 9 causes of trouble—and cures.

Design Features in New Products— 64... Linkage adjusts table tilt about two axes. Mill rolls superalloys; starters for turbo-engines—in US and USSR; ball screw speeds cycling of fatigue tester; elliptical hood spreads fertilizer evenly.

STAFF REPORT

Fiber-reinforced Plastics— 69... F. R. Park, Associate Editor
Fourteen organizations form team to collect and organize data and standards for these materials. Article covers the five basic tests, the 36 variables, and the statistical methods that are backbone of the 5-year fact-finding program.

Ball Bearings for 300 F and Up— 72... N. A. Sinclair, New Departure
Here is what happens to bearings operated above 300 F, and the special materials and lubricants needed for good performance.

Ceramics That Bounce— 76... R. H. Rudolph, Diamonite Products Mfg. Co.
Sintered alumina makes a spring good for 2000 F.

DESIGN FILE

Multifunction Overrunning Clutches— 78... W. E. Mulholland, J. L. King, Jr.
Seven examples of clutch races that do more than one job.

Stress in Short Cylindrical Shells— 81... Lawrence Berko, W. Kidde Co.
Formulas for calculating deflection, shear force, bending moment.

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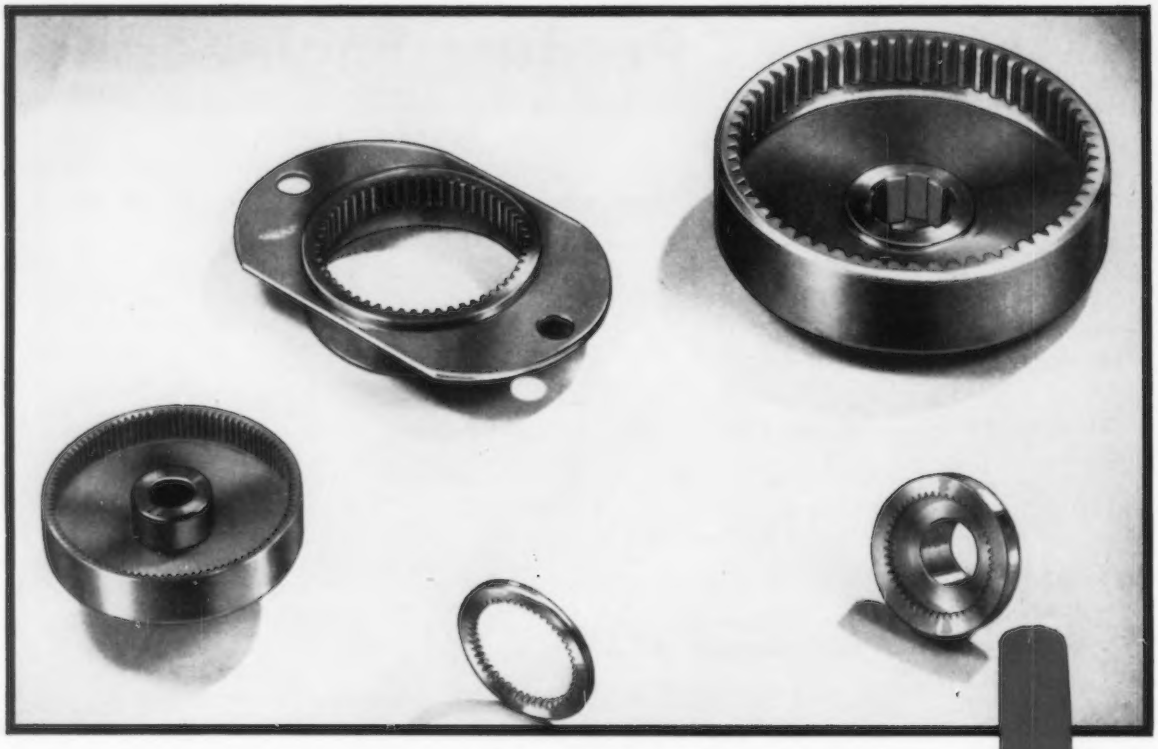

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Interesting to Note . . .

It Started With Armor

Even the brave knights of yore found it necessary to keep up with the Joneses. Once upon a time, around 1450, a knight wanted his armor decorated a little more than that of the knight next door. He took his breastplate to his friendly neighborhood armorer and with the help of a little acid had the first etched suit in history. The armorer may have been Daniel Hopfer, who used this new etching technique around 1500 to make etched portraits. Soon an entire school of art was built around Hopfer's work.

Today, all engravings for printed illustrations are made by this technique, which replaced the old hand-cut woodblocks. In this issue, for example, the drawings are printed from zinc etchings, the photographs from etched copper-halftone plates. Since the war, etching has been applied as a machining process for parts, first in the aircraft industry and more recently elsewhere. Its common name is "chemical milling," and it involves new ideas in sealants and etchants. A present-day summary appears on page 50, and two steps in the process—masking and etching—are shown on our cover.

America's First Industry

Secret processes are not as prevalent today as they were before the era of mass production and automation. Practically every craft industry was founded by a family that guarded the process as carefully as Harry Winston keeps the Hope diamond. The art of glass-making was no exception.

When the American colonies were first being settled, eight Poles and Germans were brought to Jamestown, Va. Their job: to manufacture ashes, soap, pitch, tar and glass. These men were artisans who kept their process secret even from curious Indians who would wander in and around the new settlement. Some of their glassware was shipped to England among America's first exported commodities.

A glass-house was soon built and beads were manufactured for barter among friendly Indian tribes. This early glass-house, built in 1608, was probably America's first factory. Unfortunately, the friendly Indians became irritated in 1622 and massacred the inhabitants of the glass-house, leaving Virginia to wait over a hundred years for its next glass works.

Although the glass industry has made more progress in the past

(Continued on page 7)

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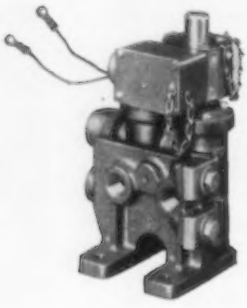
BY A MERE COIL CHANGE

Crescent® Valves are adaptable to

ANY VOLTAGE

Standard 4-Way



J.I.C. Type 4-Way

Standard 3-Way

® 4-Way and 3-Way Solenoid operated, pilot controlled valves for Air, Water and light oil to 150 P.S.I., products of Crescent Valve Co.

NO COIL BURNOUT

because a generous power margin, short solenoid travel and pilot operation combine to prevent overheating and overloading. Note that these valves are accepted and used in automotive plants where assembly line production does not permit coil or valve failure.

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Main valve design is aimed at extremely long trouble free service. Resilient seats are tight sealing and are not affected or damaged by dirt or grit because they are of a self scavenging design. Witness their superior performance in such severe service as operating hopper doors on cement batching equipment and in other dusty environment.

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Solenoids and pilot sections are interchangeable from one valve size to another, minimizing spare parts requirements. Adaptation to any practical voltage is achieved by a simple coil change.

Speed of response, speed of installation and dependable leakproof operation year in and year out are responsible for the increasing switch to Crescent valves on production machinery where time is money.

For complete data write for Catalog 6-C.

BARKSDALE VALVES

5125 Alcoa Avenue, Los Angeles 58, California

"SHEAR SEAL" 4-WAY VALVES, 0 TO 250 P.S.I. AIR

$18.50 List Price*

*$18.50 is the list price for the ¼" port size and $19.50 for the ⅜" less usual quantity discounts.

NO MORE AIR VALVE TROUBLES FROM DIRT OR CORROSION

(AND WITHOUT COSTLY FILTERS AND OILERS)

Important Savings	Low initial cost. Need no oilers and filters (time and materials savings).	All components are corrosion resistant.
Low Maintenance	Sealing qualities do not diminish with long, continued use.	Wear compensating "Shear-Seal" design.
Long Service Life	No production delays. Maintenance (rarely needed), without disturbing plumbing.	Lapped metal to metal sealing members.
Not Critical to Dirt	No scoring or binding. (As with spool or poppet designs.)	Flow is through "Shear-Seals." Sealing surfaces remain in constant intimate contact.
No Creeping Cylinders	Leakproof closure. (No internal port to port leakage.)	Maintained through lapping action of each operation.

Ask for bulletin 2801-7.

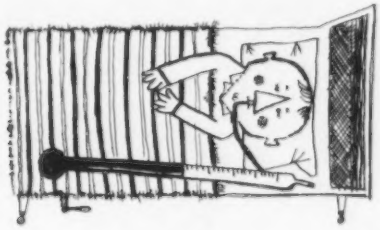
Foot operated models with or without spring return to reverse or to center are $24.50 list for the ¼" and $25.50 for the ⅜" valve less quantity discounts.

BARKSDALE VALVES

5125 Alcoa Avenue, Los Angeles 58, California

half century than in the preceding 5000 years, it is still an infant. Glass fibers, for example, are playing an important part in textiles, filters, insulation and also in reinforcing plastics. (see page 69) The applications of glass appears endless.

Good Day, Doctor



Too often a patient's, "Good day, doctor," is returned with, "Open your mouth," and insertion of a cold thermometer. What happened before the rise of the alcohol-flavored glass stick? Did doctors just return your greeting and pay no heed to temperature? Actually, medical science has long recognized the relationship between illness and temperature, but measuring the heat of the body was a complex operation.

Early thermometers were bulky devices that couldn't be moved easily. Some took several hours to record a man's fever; and a lack of standard made most readings useless. About 200 years ago, a French aristocrat named Rene Antoine de Reaumur became interested in science. Aside from his work in metal crystallization, porcelain and steel-making, Reaumur defined a scale of temperature that still bears his name. (France honored him additionally by naming a subway station after him). Reaumur's scale relied on alcohol, which seriously restricted its use. It couldn't be used industrially because its range was limited by the boiling point of alcohol. Bearings that operate at over 300 F, the subject of the article on page 72, had to wait for a more advanced system of measurement, a system too bulky to use medically.

Although Reaumur added to the knowledge of thermometry, his first interest was in the field of biology. He collected every form of life he could get his hands on. His home was decorated with shellfish, stuffed animals and preserved insects. In his laboratory, he had an aviary and a small menagerie. When Reaumur became fascinated by the world of insects, he studied extensively, then published a six-volume work on the subject. Next he turned to gastrobiology and, by placing tubes in the stomach of a bird, was able to retract and study pieces of partially digested meat. Reaumur was indeed a versatile scientist.

The End of the Scythe

When his father failed, young Cyrus McCormick felt it his personal crusade to develop the reaper. Father and son, working at night at their Virginia farm, had already developed several agricultural aids that eased their work. Their biggest concept, a machine to harvest wheat, became their biggest obstacle. They tried to make a mechanical device that would simulate the movements of a man with a scythe. Yet this graceful sweeping motion was hard to duplicate. Any type of hilly terrain meant trouble, and Virginia is rolling countryside. It was this scythe-like sweep that caused the elder McCormick to abandon his work on the reaper.

Cyrus was but 22 when he first got the idea to use a scissor-type cutter instead of the sweep. Early attempts failed. The machine was noisy and at times would scare the team of horses; it jammed or would miss patches of wheat. In one early experiment, the farmer who allowed McCormick to try out the machine on his land, called off the test, yelling, "Stop those horses! You're rattling the heads off my wheat."

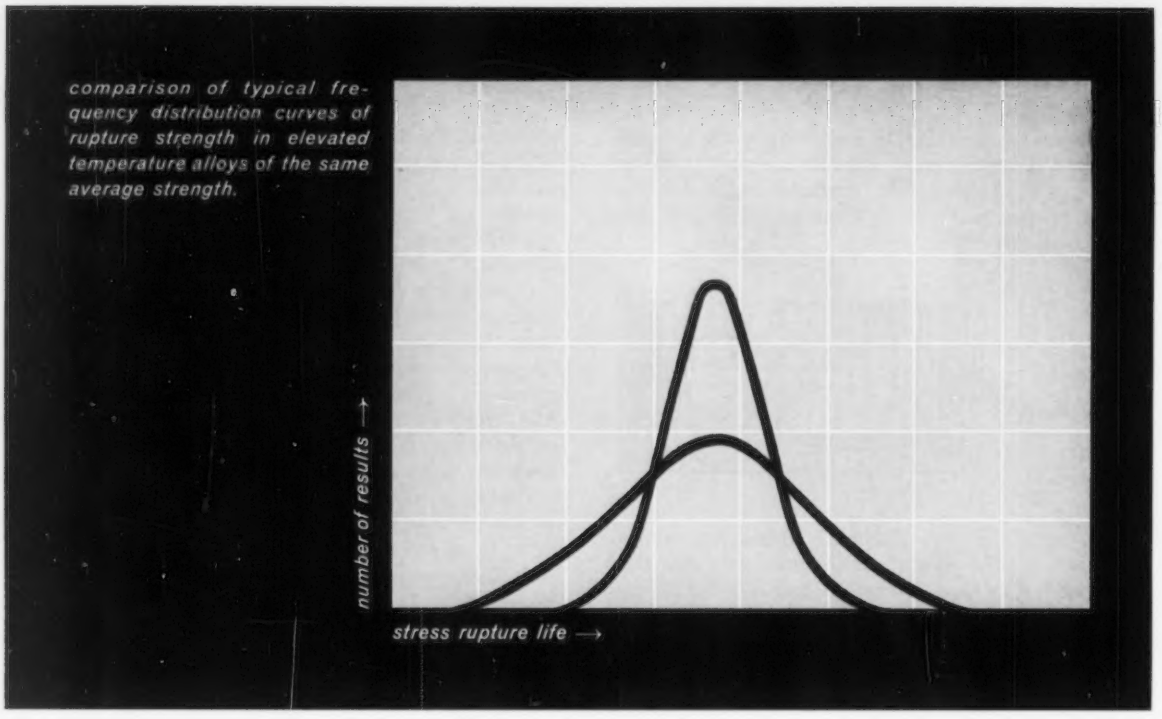
When the reaper was finally perfected, it changed the pattern of American agriculture. It freed men from small farms and began the era of the large mechanized farm. Quickly, mechanized equipment became available, allowing fewer men to farm greater areas. Plowing, planting, cultivating and harvesting by hand soon became a thing of the past. Almost every daily chore was either harnessed to a motor or a socket in the wall. One modern design feature, in a fertilizer spreader, is pictured on page 68. It does what the most skillfully wielded manure fork never could—gives each square foot the right dose of food, no more and no less.

The Eyes Have It

As every Eskimo knows, the most dreaded danger in an arctic region is snowblindness. Today there are a variety of goggles or glasses designed to protect the eyes from the bright glare of ice or snow. Before smoked or colored glass, 2000 years ago, Eskimo and Arctic dwellers found that driftwood could be carved to fit over the eyes. Then if a narrow horizontal slit was cut, it would protect the wearer against most reflected light. These were probably man's first glasses.

Historians have reported an early Chinese emperor who observed the heavens through natural lenses of rock crystal, quartz and amethyst. Yet these were not true eyeglasses. The first lenses were round and held close to the eye. The Chinese developed large oval lenses to help distinguish the fine characters of their miniscule calligraphy. Roger Bacon, the English monk-philosopher, is credited with the invention of the convex lens; an Italian priest, Salvino del Armati, is said to have made the first spectacles in 1285.

Proper eye care is a major consideration of all companies today. Research groups try to choose colors that will be relaxing and prevent eye strain; gages and dials are designed to be easier to read, see page 61; soft indirect lights are replacing the harsh glare of bare overhead bulbs. Even the social stigma of wearing glasses has been replaced by acceptance, and in some cases social advantage is a result. BENEDICT A. LEERBURGER JR.


comparison of typical frequency distribution curves of rupture strength in elevated temperature alloys of the same average strength.
number of results →
stress rupture life →

why consistency is important to every designer who uses elevated temperature alloys

The broader curve is characteristic of elevated temperature alloys generally used today. Its shape shows parts made from this alloy will have widely varying service lives.

The steep curve is typical of Carpenter alloys for elevated temperature service. It shows one reason why Carpenter alloys are becoming so widely used — they're so consistent in performance.

Fabrication properties are just as outstanding. Forge shops, fastener makers, engine builders report better finishes and fewer rejects with Carpenter high temperature alloys than with similar types produced by others. Carpenter alloys have gained an enviable reputation for exceptional cleanness, forgeability and machinability wherever they are used.

Predictable performance and outstanding fabrication properties of Carpenter elevated temperature alloys are made possible by the most exacting standards of quality control, typical of Carpenter's leadership in the technology of specialty steels.

Write today for your copy of the new booklet, "Carpenter Alloys for Elevated Temperature Service". Or ask the Carpenter representative who calls on your company. The Carpenter Steel Company, 117 W. Bern Street, Reading, Pa.

Carpenter STEEL

Improved alloys for elevated temperature service

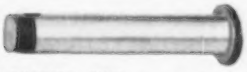
"Full-round" design of Link-Belt LXS chain avoids stress raisers

ROLLERS are accurately machined for correct operating clearances and free-rolling action.

SIDEBARS of selected steel have accurately machined "full-round" pitch holes, which maintain firm, tight press fit of pins and bushings.

FOR POWER TRANSMISSION, LXS chain is generally supplied with offset sidebars. Uniform stress distribution provides extra chain life and safe dependable operation.

FOR CONVEYING AND ELEVATING, LXS chain with straight sidebars and rollers to meet varied operating conditions. A wide variety of attachments is available.



"FULL-ROUND" PINS are made from a tough steel, specially treated for high strength in shear . . . sized for controlled press fit to prevent rotation in sidebars.

"FULL-ROUND" BUSHINGS are properly hardened to shrug off shock, resist wear . . . accurately sized for controlled press fit to prevent rotation in sidebars.

Greater live bearing area extends life

Stress concentration points are eliminated in Link-Belt LXS chain! "Full-round" design avoids sharp corners which may be the starting points of chain failure . . . provides maximum live bearing area between pin, bushing and sidebars. As a result, stress is distributed evenly . . . long chain life is assured under severe conditions.

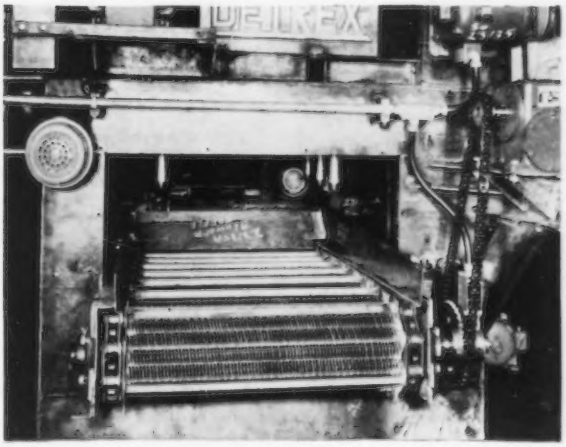
Pins and bushings of LXS chain are accurately sized . . . assuring controlled press fits, preventing rotation in sidebars. Similar accuracy in machining of sidebars permits close control of pitch and proper chain length after assembly.

Other long-life features of Link-Belt LXS chain include use of selected steels and controlled hardening of all parts. Both contribute to greater endurance . . . greater uniformity.

LXS drives stand up to impact and abrasive service

Large, live bearing area makes LXS chain ideal for exposed drives and abrasive conditions such as found on this heavy rotating drum. Uniform distribution of load over ample bearing area reduces cutting action of abrasives . . . extends chain life.

LXS chain has stamina required for long, heavy-duty conveyors



With its exceptional strength and wear resistance, Link-Belt LXS chain can easily meet rugged conveying and elevating requirements. Due to accuracy of pitch and attachment spacing, plus close matching of multiple strands, LXS has the added strength and wear life necessary for the extra-long conveyors so important to today's highly mechanized industry.

HEADQUARTERS for chains, sprockets and other Link-Belt conveying and mechanical power transmission products is your nearby Link-Belt office.

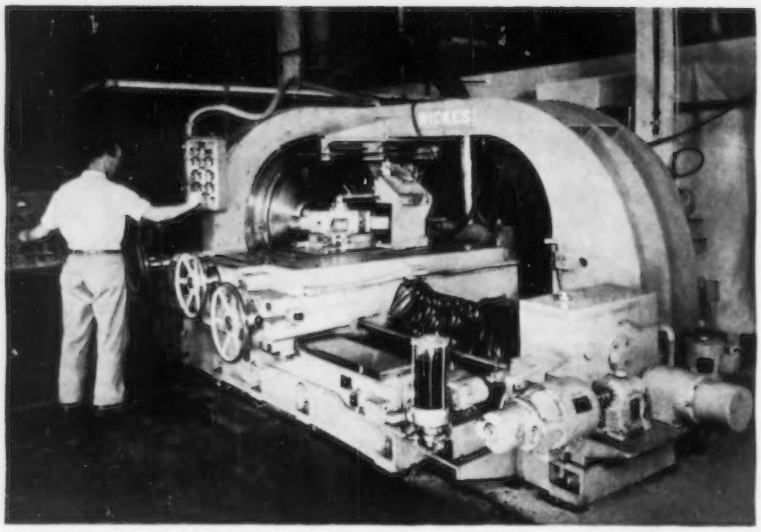
LINK-BELT

CHAINS AND SPROCKETS

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Sales Offices, Stock Carrying Factory Branch Stores and Distributors in All Principal Cities. Export Office: New York 7; Canada, Scarboro (Toronto 13); Australia, Marrickville, N.S.W.; South Africa, Springs. Representatives Throughout the World. 14,741

Designer's

New G-E 2-dimensional tracer control permits synchronized machining with balanced tool pressure



SYNCHRONIZED G-E CONTROL of tracer heads keeps cutting tools directly opposite one another even when opposite sides have different contours. This enables the Wickes automatic center-drive lathe to machine jet engine turbine wheels accurately, without wheel distortion due to tool pressure.

New to the machine-tool industry is the Wickes automatic center-drive lathe for machining jet-engine turbine wheels. Equipped with General Electric two-dimensional tracer control, it can machine ***both*** sides of a turbine wheel ***simultaneously***, maintains balanced tool pressure while cutting web thicknesses of .030 in. in production runs. At operating speeds of 100 to 250 ft per min and maximum spindle speed of 140 rpm, it meets tolerances of ± .0005 in. A 360-degree profile tracer control, it can follow any template contour, make right-angle cuts, and reverse itself, permitting greater control of equipment accuracy and savings in time and labor.

FIVE TRACER CONTROL SYSTEMS are offered by General Electric to help build fast, accurate, consistent production into a variety of machine tools.

Contact your local General Electric Apparatus Sales Office for details on G-E 2-dimensional tracer control. Check Bulletin GEA-6122 for data on G-E tracer control systems.

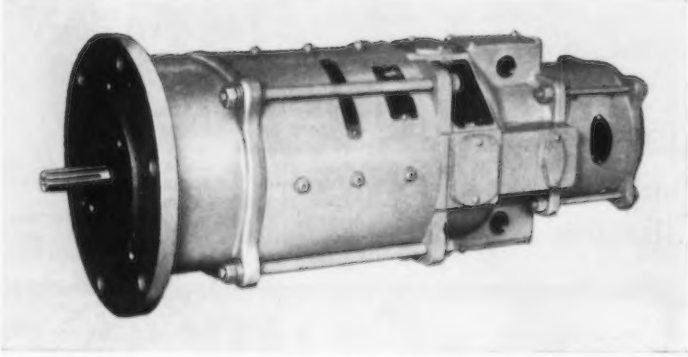
Servo motor meets fast response needs of high-speed automatic machine tools

Reaching 63% of rated speed in .015 seconds, ***extra-fast response*** is an outstanding feature of a new G-E power-packed d-c motor.

As a servo motor, it meets critical demands of automatic machine tools subject to rapid starts, stops, reversals; responds rapidly to widely fluctuating loads. An example is its use in feed drives for contour milling machines.

The 1-hp, 1-hr model shown delivers 4.6 lb-ft torque over a total speed range from 0 to 1140 rpm, has a stall torque of 32 lb-ft. High-speed backout at 2000 rpm is obtainable by applying 200 v to the armature.

Units are available with integrally housed d-c tachometer generators rated at 50 v/1000 rpm, or 100 v/1000 rpm; motors use current limited d-c power supplies. For more information, check servo motor in coupon.



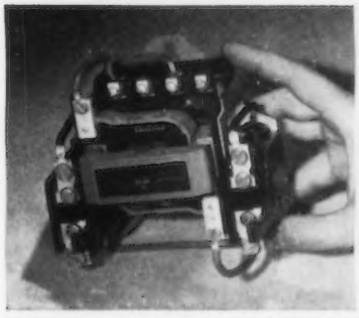
TOTALLY ENCLOSED 1-hp, 1-hr model uses Class B insulation throughout, operates on 115 volts DC at any angle.

GENERAL ELECTRIC

Digest

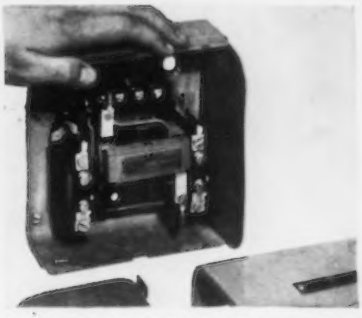
PRODUCT HIGHLIGHTS

New G-E magnetic starters in sizes 0 and 1 feature 42% smaller size and "snap-slide" construction

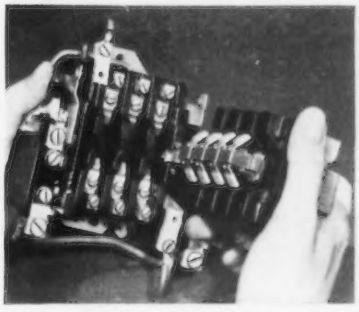


42% SMALLER than previous open forms, new G-E starter needs less mounting area, is just 4½ in. high and 5 13/32 in. wide. Built to new NEMA ratings up to 7½ hp at 220v, 10 hp at 440v, the starters are available in all forms and enclosures.

"SNAP-SLIDE" CONSTRUCTION permits all principal components to snap or slide together to simplify inspection. Disassembly takes less than a minute, with no screws to remove. Contacts can be inspected and coil removed without tools.

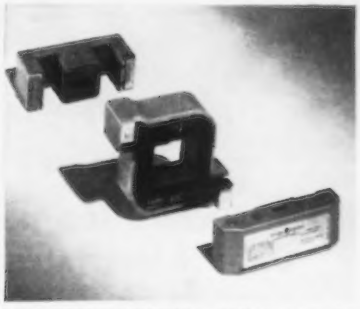


32% MORE WIRING SPACE is provided within enclosure. Removable sides permit easy wiring. Straight-through wiring eliminates need to bend or loop wires, saves time. New pressure-type terminals also make wiring easier.



NEW "VERTICAL" CONTACTS, with horizontal action, provide a wedging action for positive make, higher tip pressure and less chance of contact welding. Long-life "kick-off" spring and contact springs provide clean break of contacts.

ADJUSTABLE OVERLOADS provide maximum flexibility to meet special installation requirements, particularly varying ambient temperatures. A new finger-tip adjustment of the overload relay allows easy setting of from ±15% of nominal heater rating.



COIL INRUSH CURRENT is 27% less in the new starter. This means you can use a 47% lower rated control transformer on your circuit. Mylar* insulation on coil start wire provides longer coil life.

*Registered trademark of DuPont Company.

Radically different in design, General Electric's all-new "100 LINE" Size 0 and 1 motor starters offer machine-tool builders scores of new features for easier installation, longer starter life, and greater flexibility. For example, reversing starters can be obtained with vertical or horizontal interlocking. In addition, JIC forms are available. Nine modification kits—most complete line today—permit even greater flexibility. See Bulletin GEA-6611.

General Electric Co., Apparatus Sales Division, Section A668-136, Schenectady 5, N. Y.

Please send me the following:

√ for reference purposes X for immediate project

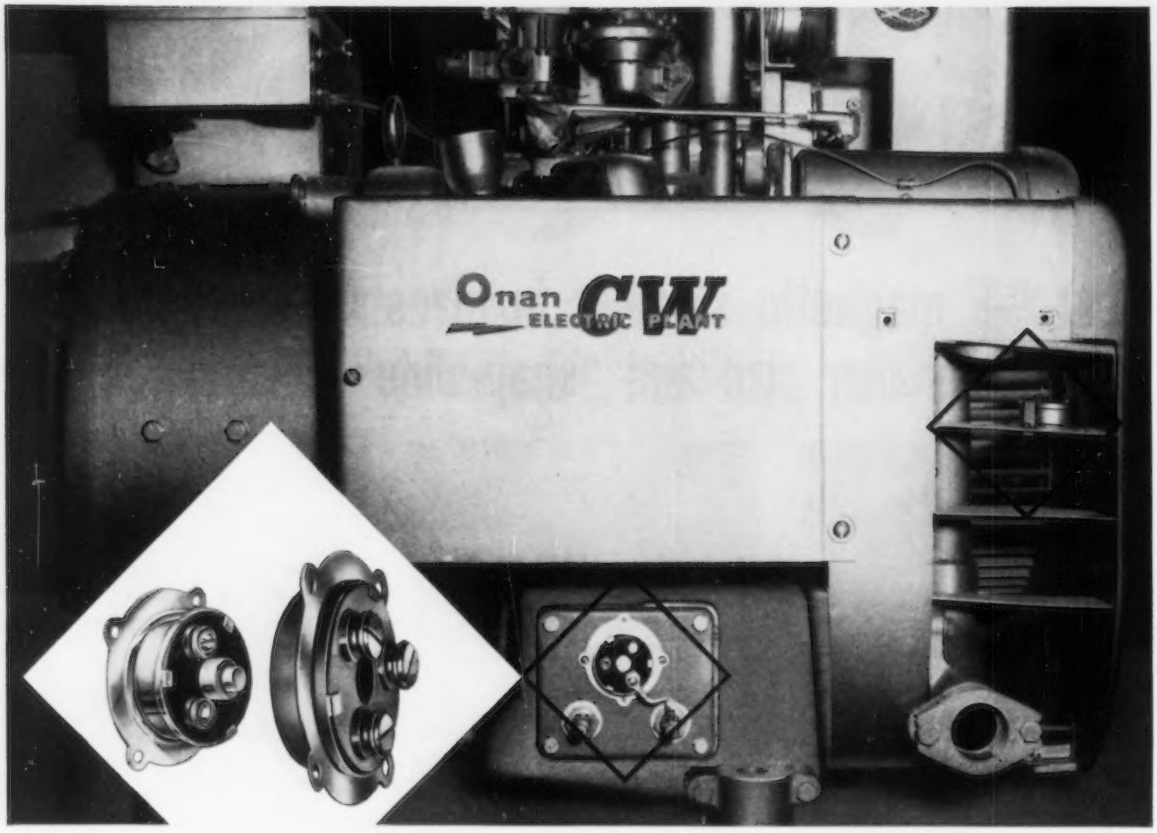
☐ GEA-6122 Tracer control systems

☐ GEA-6611 Magnetic starters Sizes 0 and 1

☐ Servo motor

Name ..... Company .....

City ..... State .....



This is the Onan CW Electric Generating Plant which uses one Klixon Thermostat to keep oil in the oil base at a set temperature to facilitate cold weather starting and another as an overheat safety cut-off. These Onan 7½ and 10KW electric plants play an important role in long line natural gas transmission and many other industrial operations.

KLIXON

FIXED TEMPERATURE CONTROLS

Assure top performance in Onan Electric Generating Plants

D. W. Onan & Sons Inc., of Minneapolis, manufactures a complete line of electric generating plants for emergency standby service, for portable service, for mobile service and for stationary service. And, says R. O. Overby, Assistant Chief Engineer for Onan:

"We have been using Klixon Thermostats for many years in safety cut-off devices and in temperature control applications on our generator sets. They have proven to be highly effective, dependable and economical. As a result, we give first consideration to Klixon when any new temperature control requirement comes up in our products."

Among the many Onan plants using the Klixon fixed temperature controls are the Onan water-cooled marine models, the air-cooled models which are equipped with automatic air shutters and the various standby units which utilize oil base heaters.

Onan is one more company on the long list of equipment manufacturers who continually specify and use Klixon Controls.

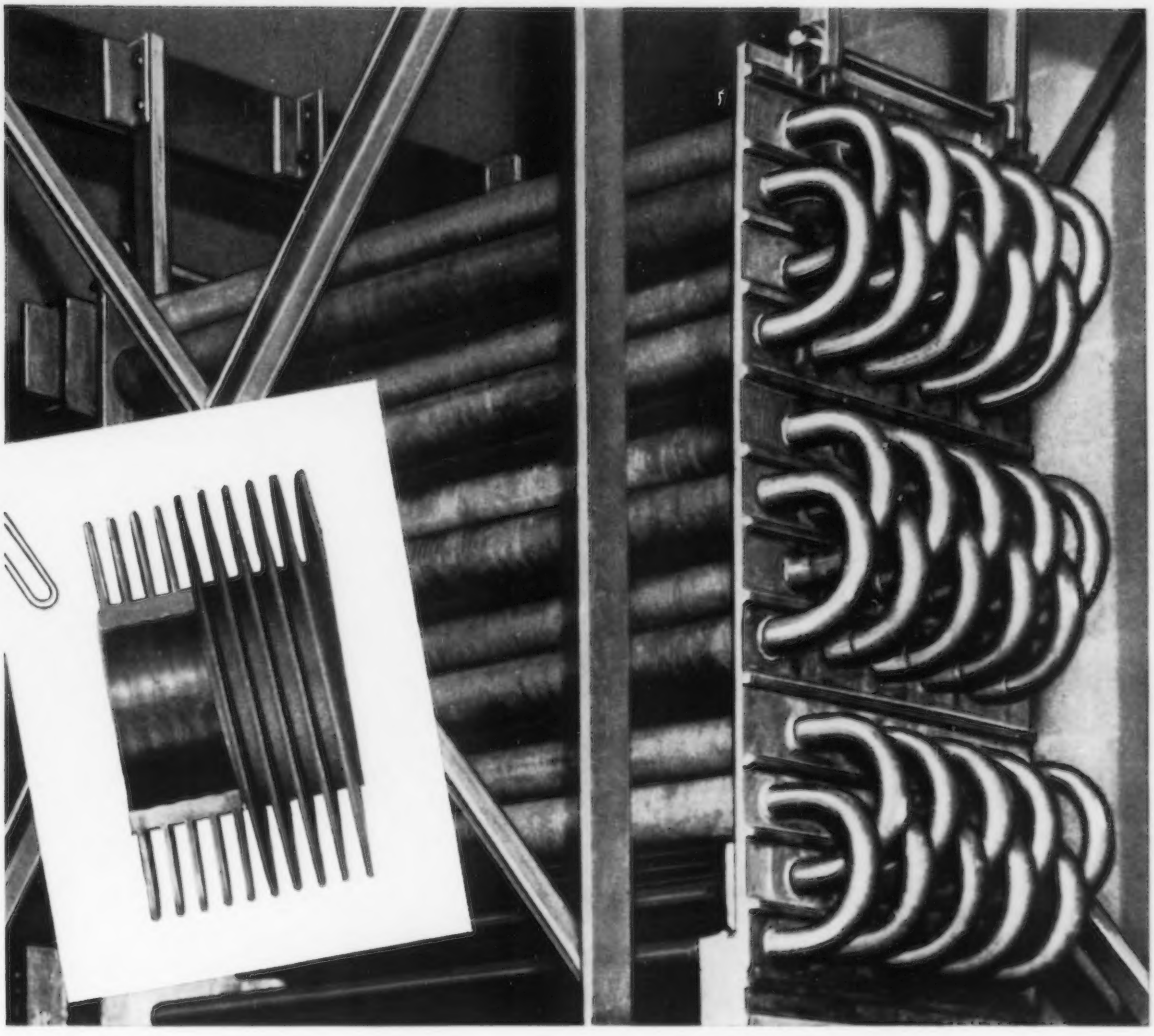
Klixon Controls are available in many hermetically sealed and open types in a wide variety of operating temperature ranges. Klixon engineers, specialists in temperature control applications, can help you work out your specific application details. Write for THSN catalog sheets.

Typical KLIXON Fixed Temperature Controls used in many applications, including examples of the new 202 series for home appliances.

METALS & CONTROLS CORPORATION

Spencer Thermostat Division 3802 Forest Street, Attleboro, Mass.

KLIXON®



General Plate Stainless Clad Copper Enables Griscom-Russell K-Fins

To Meet 2600°F Operating Conditions

Two metals are often better than one, and here's a case in point...

In Griscom-Russell's K-Fin tubing for high temperature gas to liquid heat exchangers, General Plate Stainless Clad Copper reduces fin tip temperatures 29% (2090°F to 1475°F) with nearly twice the heat transfer rate of unclad stainless.

Benefits? Fin tip temperatures in G. R. K-Fin run well below the oxidation point — fin life is greatly extended — heat exchanger performance is improved substantially — with worth while economies in design.

G. P. Stainless Clad Copper is available in widths up to 13" and thicknesses up to 1/16", single or double clad, in long lengths. It can be blanked, drawn, spun, formed, brazed, and spot or seam welded.

Let us send complete information on G. P. Stainless Clad Copper — it may be just what you have been looking for. Write today for Catalog Sheet 727C.

You can profit by using General Plate Clad Metals.

METALS & CONTROLS CORPORATION

General Plate Division 1002 Forest Street, Attleboro, Mass.

FIELD OFFICES: NEW YORK, CHICAGO, DETROIT, MILWAUKEE, LOS ANGELES

A.O. Smith offers 24-48 hr.

All types, 1/3 to 800 hp . . .

Any of the standard motors listed at right can be furnished from stock in strategically located A. O. Smith warehouses. Even motors requiring minor modifications can be shipped from the factory within 72 hours.

motor delivery everywhere!

- **FRACTIONAL 1/3 to 1 HP — single or polyphase, rigid or resilient base, open drip-proof, TENV or TEFC.**
- **SINGLE PHASE INTEGRALS 1 to 5 HP in both old and current NEMA frames, open drip-proof and TEFC.**
- **POLYPHASE INTEGRALS 1 to 800 HP in both old and current NEMA frames, open drip-proof, TEFC and Explosion-proof types.**
- **VERTICAL HOLLOW SHAFTS 1 to 700 HP in weather protected, TEFC or Explosion-proof models. P and PH bases. With or without non-reverse ratchets.**
- **VERTICAL SOLID SHAFTS 1 to 800 HP. Normal and high thrust. Old and current NEMA frames. Open drip-proof TEFC, Explosion-proof.**
- **FACE MOUNTED PUMP MOTORS 1 to 75 HP. C-Face, D-Flange and Close-Coupled types in open drip-proof, TEFC and Explosion-proof models.**
- **JET PUMP MOTORS 1/3 to 3 HP available in single-phase capacitor start or polyphase induction motors. Open drip-proof and TENV models with standard keyed or stainless steel threaded shafts.**

Call your

A. O. Smith motor man COLLECT

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BETTENDORF, IOWA	DAvenport 5-0771
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CHICAGO 4, ILLINOIS	WAbash 2-6212
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DENVER 10, COLORADO	PEarl 3-5547
DETROIT, MICHIGAN	WOodward 1-7090
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CORPORATION

ELECTRIC MOTORS

Tipp City, Ohio

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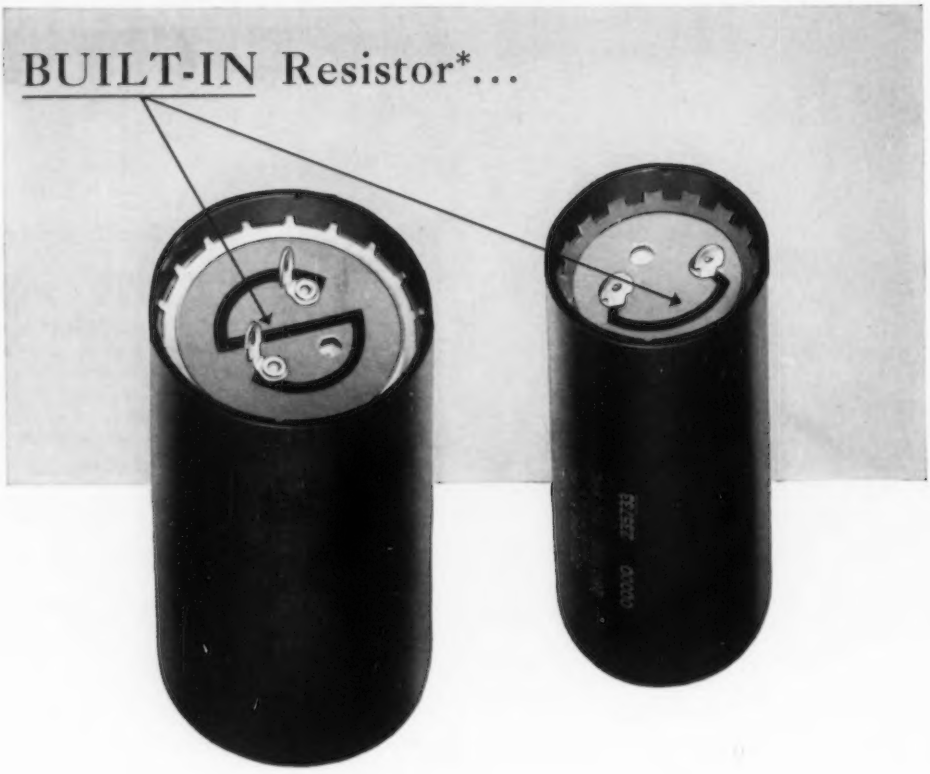
New Mallory Motor Starting Capacitors

with BUILT-IN Resistor*...



Cut Assembly Time and Costs

Now—instead of soldering a separate resistor across the terminals of a motor starting capacitor, install *both* the capacitor and the resistor in one operation—with the new Mallory Motor-Starts. These capacitors have the bleeder resistor deposited, by an exclusive Mallory process, on the top wafer board—between the contact terminals.

The new Mallory design leaves terminals completely free of obstructions. It not only offers space savings, but enables substantial reductions in the time and cost of installing the capacitor in electrical equipment.

This is the latest in a long series of Mallory developments that have improved the compactness, dependability and current ratings of motor starting capacitors. Application of this new design can bring you extra economy on your next production run. Write for complete technical and application information—or, if you prefer, a consultation by a Mallory capacitor engineer.

**Patent applied for*

Serving Industry with These Products:

Electromechanical — Resistors • Switches • Tuning Devices • Vibrators
Electrochemical — Capacitors • Mercury and Zinc-Carbon Batteries
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Parts distributors in all major cities stock Mallory standard components for your convenience.

Expect more . . . get more from

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MALLORY

P. R. MALLORY & CO. Inc., INDIANAPOLIS 6, INDIANA

DEVELOPMENTS TO WATCH...

Titanium can be remelted...

. . . Watertown Arsenal metallurgists report. They're using a graphite crucible with a protective "skull" of titanium at the bottom, and adjusting the power input so a meniscus can be held in the molten metal. That way they reduce contact between the titanium and the graphite to a point where carbon contamination is "appreciably lower than any reported in the technical literature." Carbon content of the remelted metal ranges from 0.13% to 0.22%, and the metal "appears to be acceptable for many engineering structures and components, excluding those fabricated by welding."

For motor controls, home appliances . . .

. . . welding equipment, and power relays, General Electric is developing **silicon-controlled rectifiers** which its engineers believe will "find wide use as a combination electric power relay switch and conversion device."

These are three-electrode units, more complex than standard rectifiers, but apparently also more versatile. GE says they'll perform the same function as the gas thyratron, may also replace magnetic amplifiers and serve as voltage regulators. Furthermore, they're about 1/100 the size of the thyratrons, have "virtually unlimited life," and should be serviceable at temperatures of 300 F or more.

"Eventually," says H. B. Fancher, general manager of GE's Semiconductor Department, "they may be used extensively in kitchen food mixers, electric stoves, weather-conditioning equipment, and lighting controls . . . and may extend the use of simplifying, long-life electronic circuitry in many new mass markets that were previously closed because large, power-consuming, short-life electronic components were the only ones available." So far, only prototype units have been built.

Commercial introduction of the new silicon-controlled rectifiers is not expected until near the end of the year.

Fluoroscopes are better than X-ray film...

. . . for detecting flaws in aluminum and magnesium castings, Chance-Vought Aircraft reports. C-V has been testing the newly developed high-intensity fluoroscope pictured here, says the method saves both time and money, often spots sand inclusions and other flaws that are missed on X-ray film. A permanent record can be made, too, as the camera mounted at the operator's left indicates.

So far, X-ray tubes of relatively standard design have been used, but C-V is now getting one with a beryllium window (to minimize radiation absorption), hopes that the new tube will permit detection of microshrinkage.

Fault-finding fluoroscope is operated by remote control. Inside shielded room, castings are placed on turntable topped by plastic "bubble" to hold them so they can be rotated on any axis for inspection.

DEVELOPMENTS TO WATCH...

Trend to 400-cycle equipment...

. . . in machine and power tools as well as aircraft and lighting can bring a good many design advantages and open new equipment markets, Ideal Electric & Mfg. Co. points out. Big advantage of 400 cycle is that it permits higher-speed motors and smaller, lighter-weight components; but it has sideline advantages as well. Magnetic amplifier controls for machine tools, for instance, work faster on 400-cycle current than on standard 60-cycle. (Note: A major P. E. article on the use of equipment that operates on 400-cycle current for machine-tool control is now in preparation.)

Future power sources...

. . . Soviet scientist Georgi Babat predicts, will include the energy of light (as utilized in photon, or quantum, propulsion), the thermal energy of the earth's core and the plasma reactor (magnetically controlled, ultra-high-temperature gases). He speaks, too, of using the molecular energy of the air (an apparent reference to free radicals, but with the molecular fragments being obtained by compression of the air). These are not in themselves new ideas. They're already under intense discussion here (Oct. 7, p. 15). But he has some interesting suggestions.

He foresees an artificial "sun" to warm the arctic, created by suspending a plasma (thermonuclear) reactor magnetically above the polar regions.

New photocells for printed-tape reading...

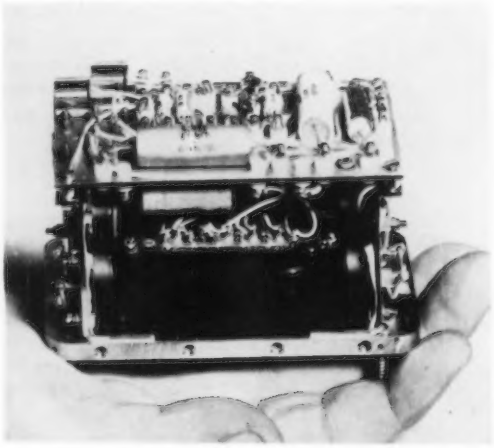
. . . and others to work in counters, door-openers, and a wide range of motor-operated and relay-operated devices, are being developed at Canadian Marconi Company's laboratories as additions to its present HD series of photoconductive units. Latest development is a tiny cell with a sensitive area about 2 mm by $\frac{1}{2}$ mm, specifically designed for the punched-tape application. These, like other recently introduced Canadian Marconi products (Dec. 23, p. 104) use cadmium-sulfide semiconductors.

Design standards for timing mechanisms...

. . . signal generators, and the like are being tightened as new testing and calibration devices are introduced. One example is pictured here—a miniaturized electronic frequency standard for aircraft instruments. Others include the new "tester for electronic testers," a highly accurate power meter and voltage ratio calibrator developed for the Air Force (Dec. 2, p. 10); and Naval Ordnance Lab's "extreme accuracy calibrator" for checking electronic test sets and other circuitry. This Navy one combines an electronic analyzer with a miniature timer, a multimeter and a regulated power supply.

The Hamilton frequency standard is a bimetal tuning fork (a nickel steel-carbon steel laminate), controlled by a transistorized circuit. Hamilton's vice-president D. J. Jones says it's so accurate that it "would take four months to accumulate an error of only one second."

Photo shows prototype, but Hamilton says it's now ready to produce the unit for aircraft, nuclear and other uses. —ARG



Electronic tuning fork is miniaturized, transistorized unit, holds timing constant to 1 part in 10 million, even when operated at temperatures above 21.

For the Technical—the Subliminal

NEW ORLEANS, LA.—What may prove a national shot-in-the-arm to education, industrial training, and perhaps even an adjunct to advertising, is a new communications concept known as "subliminal perception."

It presents an idea to a person to which he may respond without ever being aware of it. This is done by flashing a word or words on a television or motion-picture screen while a picture is being shown. Flashing is so rapid that the words cannot be consciously recognized, but those watching the film will see and can react to this visual information at the preconscious level of awareness.

Oftimes referred to as "brainwashing," sneaky advertising," and the like, it has created a fear that people may be forced to do something they won't want to do.

Precon Process and Equipment Corp. of New Orleans, which has been developing the idea and equipment for this method of communication for the last seven years, is trying to dispel this fear. "Much of the mental activity that determines a person's responses is done without his realizing it—at a preconscious level."

According to statistics, there is much evidence to indicate that a large portion of the mental activity that results in our responses is without conscious awareness. By the same means, we do not "see" or "hear" things we do not wish to.

Of particular interest to the technical world are the possibilities for science education posed by Precon. It has been shown that extended exposure, such as for a semester of study, to subliminal projection serves to impress information on the preconscious of even the most obdurate of students without interfering with messages being consciously received.

Example: in a film of basic electricity, Ohm's law might be subliminally projected in its varied forms while a series of electrical operations were being presented to the conscious. Precon is known to heighten student interest, thus chip away at preconceived notions of inadequacy.

Killian's Influence Soon Tested

WASHINGTON—The next few months will determine if the President's new advisor on science and technology, Dr. James R. Killian, is to exert a strong influence in shaping the Nation's scientific efforts, including defense or become another office that makes reports to gather dust.

Killian has firm ideas about what is needed to overhaul the Nation's scientific efforts: "Clearly, the problem before us is not leadership and technological strength today. The challenge we face is the maintenance of this position tomorrow against the challenge of the surging technological revolution occurring in other countries."

Three major problem areas on which Killian intends to concentrate:

• Achieving a better balance between basic research and applied research and development—between fundamental ideas and hardware and gadgets. It is not only a need for more effort in basic research, Killian says, but for more "continuity of effort in all research." Too much of our research has been subject to stops and starts and changing levels of support or short-term financing, Killian believes. Killian also wants to modernize and "invigorate" science education, but not at the expense of teaching the humanities.

• Next, Killian wants to dispel some "strange notions" that science is "vocational, materialistic and anti-humanistic." Killian places much of the blame for this on scientists. He wants them to give the public a better understanding of their work.

This "scientific literacy" among rank and file Americans will ultimately determine how far the US progresses in technology, Killian says.

• The third area in Killian's program is for more "emphasis in our society on the value of intellectual discipline and on the importance of content rather than method. "In recent years," Killian claims, "we have been managing to get along in the United States by displaying an attitude of condescension toward hard work in our schools."

To overcome this, Killian wants more stress on "rigorous teaching" of intellectual skills, and on higher standards for both teachers and pupils.

To back up Killian, the President transferred the Science Advisory Committee from the Office of Defense Mobilization and put it directly on the White House rolls. In effect, it became Killian's staff. At the same time, the President, added five new members to its ranks, giving it a total of 17 members and five consultants (see box). The group—composed of 13 physicists, 3 chemists, 4 engineers, and one biologist—are top level scientists that advise the government on its scientific programs. Killian was head of this group, but because of his increased duties, he will pick another to replace him.

Killian, himself can make no de-

President's Science Advisory Committee

MEMBERS—Dr. Isidor I. Rabbi, Physics Prof., Columbia; Dr. William O. Baker, Vice President (Research) Bell Labs; Dr. Lloyd V. Berkner, Pres., Associated Univ. Inc.; Dr. Hans A. Bethe, Physics Prof., Cornell; Dr. Detlev W. Bronk, Pres. National Academy of Sciences; Dr. James B. Fisk, Exec. Vice President, Bell Labs; Dr. George B. Kistiakowsky, Chemistry Prof., Harvard; Dr. E. M. Purcell, Physics Prof., Harvard; Dr. Herbert York, Director of Livermore Laboratory; Dr. Robert F. Bacher, Physics Prof., Calif. Institute of Technology; Gen. James H. Doolittle, Vice President, Shell Oil Co.; Dr. Caryl P. Haskins, Pres., Carnegie Institute of Washington; Dr. Edwin H. Land, Pres., Polaroid Corp.; Dr. H. P. Robertson, Physics Prof., Calif. Institute of Technology; Dr. Jerome B. Wiesner, Director, M. I. T. Research Lab of Electronics; Dr. Jerrold R. Zacharias, Physics Prof., M. I. T.

CONSULTANTS—Dr. Hugh L. Dryden, NACA Director; Dr. Albert G. Hill, Director of Research, Pentagon Weapons Systems Evaluation Group; Dr. Emanuel R. Piore, IBM Director of Research; Dr. Herbert Scoville, Jr., Washington, D. C.; Dr. Alan T. Waterman, Director, National Science Foundation.

cisions, but he does have the responsibility of advising the President. This obviously is an influential spot. If the President is sold on a program, he can take action. And it is in this manner that Killian's weight will be felt.

As might be expected, Killian is looked on to be most effective in the fields of education, scientific information, and basic research. Just what influence he will have on the nation's missile and weaponry programs is hard to predict.

Killian has split the Science Advisory Committee into a score of panels of three to four members each. In some cases he drew from outside the committee ranks to get the best qualified men possible working on specific problems. They range from panels on education and scientific information to missiles and outer space.

He has dispatched these panel members across the country to missile bases and testing centers to get the information he wants. Killian himself does little traveling. He sticks close to his office where on any given day he is likely to talk with a half-dozen of the panel members by telephone and see a like number in his office.

Killian is credited with being the chief advisor behind Eisenhower's demands for a freer flow of scientific information between the allied countries. Also, he reviewed the administration's Aid to Scientific Education Program announced by the Dept. of Health, Education and Welfare.

REAL TEST TO COME

Killian's real test is yet to come, however. Up to now, he has been advising without the benefit of his committee work to back him up. As one source close to Killian put it, "The cart is before the horse." The administration programs have been formulated and sent to Congress before Killian has had a chance to really know what recommendations he may want to make.

As Congress becomes embroiled in legislating the government's scientific programs it is sure to want the benefit of Killian's thinking. At present, Killian does not intend to appear before the Congressional Committees. It is a prerogative of the president's staff to stay away. The legislators, however, are free to call on the individual Science Advisory Committee members.

Killian will likely have a lot of recommendations, that can be handled administratively. For these he—through the president—will likely try to work them out with the individual agency concerned.

RUSSIAN TRANSLATION

One group from his Scientific Committee is working on just such a situation now. This is the problem of getting a major sized program underway to translate and circulate Russian technical information. To do this, Killian's panel is working with several government agencies – National Science Foundation, Commerce, Intelligence Agencies, etc.—plus commercial organizations. Their plan is to find the best method of handling the matter, then get the various agencies to fit into the program.

The hard test will be if Killian makes a bid to tamper in the missiles and space programs. Although Killian and Secy. of Defense Neil H. McElroy are old friends, they are both carrying new brooms—McElroy preceded Killian into office by only a couple of months. And, McElroy is currently being besieged with advice on how to run his programs. He may not welcome further intrusions. However, it was our missile lag that prompted the president to appoint Killian to his post. In effect, it was a mandate to stir up recommendations in this area, wanted or not by the Pentagon.

What's the Answer?

DETROIT — The simplified-drafting controversy is still with us. Assistant Dean Gerardi of the College of Engineering of Detroit recently said this about simplified-drafting proposals: "When delegates from US, Britain, and Canada met in Toronto to discuss simplification of drafting practices in those countries, 48 industry and defense representatives from those nations were present.

"US delegation received its authority from the ASA; British representatives from the British Standards Institute; Canadians from the Canadian Standards Assoc. Question: How much time was alloted to techniques of simplified delineation? Answer: none. How much time was devoted to interpretation? Twelve hours a day, at least, with each delegation chairman working extra hours."

Are we to assume, queries Dean Gerardi, that all of these men were so stupid that if the savings in cost in the delineation of a drawing were as great as claimed by the proponents of simplified drafting, the delegates would not have thought it wise to spend at least a morning session to consider these practices?

A-powered Airliners Years Away

LONDON—At the present state of knowledge, development of a nuclear-powered airliner can be "ruled out" according to A. A. Lombard, chief engineer Rolls-Royce Aeroengine Div.

Lombard, addressing a meeting of the Royal Aeronautical Society, said that although the feasibility of a military nuclear-powered aircraft may someday be demonstrated, the gulf between first demonstration and military operation may be "very great."

As far as aircraft are concerned, he said, nuclear power remains an "extremely difficult technical problem —as yet unsolved."

There would have to be an "immense effort" to solve the two main problems: shielding weight and reactor safety. If there were a military need for such an aircraft, however, it could be built, and Lombard thought that possibly the US nuclear-powered-aircraft projects had been sponsored on this basis.

The potential rewards for such an aircraft were marginal, he said, and an operational demand for the major characteristics of nuclear power—exceptional endurance—are not apparent.

"A nuclear reactor," Lombard explained, "is a heat source, and it replaces the usual combustion system. Its main attraction is its high heat release per unit of mass, many thousands of times greater than that of chemical fuels. The result is extremely low fuel consumption, permitting full power production for days or weeks."

See-hear Phone System Gets Push from GE, Bell Labs

SYRACUSE — Two-way audio-video phone calls may be common in a few years according to William J. Morlock, general manager of General Electric's Technical Products Dept. He reports that a system for transmitting pictures over conventional telephone lines was recently demonstrated to armed forces representatives. The first hookup for the military will be made early this year; GE predicts that phone owners may have it in homes and offices within three years. The combination of audio-video over non-coaxial telephone lines is accomplished by a slow-scan picture-transmission technique that transmits an image about every 5 sec instead of the 30 frame-per-sec transmission rate of commercial TV. This principle, he says, reduces the bandwidth necessary for transmission over regular telephone lines.

Unlike conventional TV transmission, GE's program and Bell Lab's earlier "picture-phone" system present a series of still, rather than, moving pictures. Bell can transmit a small (1 by 1½ in. to 2 by 3 in.) picture at 2-sec intervals over ordinary telephone wires. Bell says that with further research, equipment could be offered as a separate, optional telephone service. Engineers are working on more compact systems that will eventually replace present experimental versions. So far they have come up with a small suitcase-size unit that incorporates camera and screen in the same housing. Another model features a separately-mounted camera and tube-like viewing receiver.

To function at optimum performance, Bell's system needs only the daylight ordinarily found in a bright room, or moderate amounts of artificial light. In coast-to-coast tests, callers could recognize each other sitting several feet from the camera.

In the commercially feasible system Bell envisions callers will dial as usual and, if the picture switch at each end is turned on, will be able to see as well as hear each other. In telephoning, the caller checks his position in front of the camera by looking into a guide. As long as he is within guide bounds, he's in proper focus.

See where you can't be . . .

Two-in-one picture-phone developed by Bell Labs provides 2-by-3-in. image. Camera protrudes above screen; knobs actuate set, define reception. Other unit has separately mounted miniature camera, tube-like viewer. When fully developed, compact units may be installed in home or office with one additional telephone line.

Testing Designs for Space

UNION, N. J.—What are the extreme combinations of temperature, vacuum, radiation and other physical conditions that environmental equipment must simulate to test materials and components put into vehicles headed beyond 75,000 ft?

This question is of prime importance to the Air Force in setting specifications for contractors. Answers have been provided, at least to the limits of present knowledge of the upper atmosphere, by two RCA engineers—R. A. Di Taranto and J. J. Lamb—on contract with Wright Air Development Center. Their conclusions were reviewed at a meeting here of the Institute of Environmental Engineers, hosted by Tenney Engineering Co.

The RCA study—first of three on environmental test equipment—considers both natural high altitude environment as it exists in the absence of man-made vehicles, and induced environments that result from the interaction of a vehicle and the natural environment.

Four vehicle concepts now under Air Force development were considered. The report isolates the combination and intensity of conditions each vehicle type will encounter on the way up, and the harmful effects the environment could have on its structure, electronic equipment and mechanical parts.

The AF concepts covered were:

- Sustained flight vehicles that gain most of their lift from aerodynamic forces. A maximum height of 150,000 ft is considered.
- Boost glide vehicles powered during the first few seconds of flight to an altitude of 100,000 ft to 300,000 ft at a maximum speed of 18,000.
- Ballistic vehicles that are powered during initial flight through the atmosphere then follow a ballistic trajectory to the target. The vehicle rises to 75,000 ft at 11,000 mph and to 450,000 ft at 10,000 mph.
- Satellite vehicles that are placed in orbit with altitude and speed limits of 350,000 ft and 20,000 mph.

The report is available through WADC.

Ask College Prexies for Prep Advice

PORTLAND, ORE.—Heads of nine Oregon colleges and universities have accepted with enthusiasm an invitation from the local school board to examine the district's college-preparatory curriculum. Object is to find out how good a job is being done and what is needed to make it better.

Dr. O. Meredith Wilson, president of the U. of Oregon, said the experiment could revolutionize the colleges by redefining the rate of progress through the first 12 grades.

UK Leads and Lags US in Plane-making Techniques

LONDON—British aircraft production engineers were told by Boyd K. Bucey, Boeing's vice president of manufacturing, that they were "ahead of USA in techniques for lower-quantity production." He was replying to questions posed by avid production experts who gather annually at Southampton U. to discuss aircraft-production problems.

Theme of the two day conference was "US–UK practice," but interest in Boeing practice proved so keen that Bucey virtually monopolized the whole discussion period.

Many of Bucey's comments were well received by the British audience. And he was in tune with an old British grievance: "Manufacturing engineers should be on the same level as designers."

But Bucey stressed the need for production engineers to keep current. He also envied the British system by which the status and quality of production engineers was maintained by professional and academic examination. "There is no similar provision in the US."

A revue of the latest British equipment occupied the second session. It was read by L. G. Burnard, assistant to the general manager of Vickers Armstrong, Ltd. Main feature emphasized here was the extensive development of heavy-duty routing during the last few years. This technique is largely intended to avoid the huge multi-thousand-ton presses available in the US, but beyond the capital resources of British industry, which could not fully utilize them anyway. Many experts were impressed with a numerically controlled pipe-bending machine developed by Vickers Armstrong (aircraft) Ltd.

Fabrication of the swept wing for the supersonic P1 fighter was the subject for the last session. It was read by chief designer F. Bradford and development engineer G. H. Taylor of the English Electric Co.

Several engineers asked why an integral wing panel had not been used in the tank area, and commented on the fact that no stretch forming had been used on the wing. The reason, said the chief designer for the fabricated skin, was simply that aluminum suppliers failed to come up with 2,000-lb billets big enough for an integral panel.

Though these billets became available, a switch now would involve a complete change in assembly technique because of access problems, according to Taylor.

But he said integral construction wasn't wanted, except on a research machine. "It was quicker and cheaper with quantity production during an emergency to break the wing skin down into small pieces," Taylor asserted. Weight advantage of integral construction, he said, then lost some of its importance.

The absence of castings on the P1 drew comment from a number of delegates who along with Bucey criticized the casting industry for not having matched their development with postwar requirements.

COMING EVENTS

FEBRUARY

2-7 . . . . AIEE Winter General Meeting. Hotels Statler and Sheraton-McAlpin N. Y. Features the largest technical program in the history of the Institute. Thomas J. Watson, Chairman of the Board, IBM, feature speaker.

4-6 . . . . SPI Reinforced Plastics Div., Technical and Management Conference, Edgewater Beach Hotel, Chicago.

13-15 . . . . National Society of Professional Engineers, Spring Meeting, Michigan State Univ., East Lansing, Mich.

MARCH

3-6 . . . . ASME Gas Turbine Div., Conf. & Exhibit, Shoreham Hotel, Wash.

12-14 . . . . Pressed Metal Institute, Spring Technical Meeting, Sheraton-Cadillac Hotel, Detroit, Mich.

16-21 . . . . 4th Nuclear Engineering and Science Conference, managed by American Institute of Chemical Engineers with participation by ASME, AIEE, American Institute of Mineral, Metallurgical, and Petroleum Engineers, International Amphitheater, Chicago.

Foamed Room With a View

DANVERS, MASS.—Lightweight huts of rigid urethane foam covered inside and out with a thin skin of aluminum are being manufactured by Craig Systems, Inc. here.

The shelters, trademarked Helicop-Huts, can be transported easily by helicopter or truck, or put on rollers for mobility. Helicop-Huts have particular application for the armed services as traffic-control and message centers, weather stations and photo labs.

The urethane foam is poured as a liquid between the formed sheets of aluminum. After it has been poured in liquid form it then expands to 30 times its liquid volume, and becomes a rigid, superior insulation.

While designed for the military, the Helicop-Hut can be sold commercially as disaster and emergency shelters, maintenance shops, microwave stations, and field quarters for construction and prospecting companies.

Helicop-Hut on the move . . . can also ride truck, roll on its own wheels. Urethane foam between aluminum walls makes shelters lightweight.

Quiet, Please— French Jets Taking Off

BORDEAUX-MERIGNAC, FRANCE— A mobile silencer for jet engine run-ups has been tested here on the Super Mystere fighter. It was developed by the French concern Boet, at the request of Avions Dassault, French builder of the Super Mystere.

French and foreign officials, including US and Indian military representatives, were given a demonstration of jet noise reduction utilizing a mobile intake and exhaust suppressor. The nose and tail units can be attached by four men in less than four min.

The exhaust suppressor, weighing about 33 tons, is mounted on three rails and has a pushbutton-controlled motor drive. The suppressor is positioned directly behind the jet tail pipe. Main emphasis in the design of the exhaust unit was rapid hook-up to the aircraft tailpipe. This is done with two clamshell doors. These doors act as flexible coupling sections for pitch motions of the tailpipe resulting from thrust changes.

Boet officials say the suppressor couplings could use differently contoured seals to fit aircraft with characteristics similar to those of the "Super Mystere." Their unit was designed especially for the Dassault fighter.

Employes Fact Hungry

NEW YORK—Employes want to know more than management tells them about their company's competitive position and new products and processes. W. A. Dobson of Savage-Lewis Inc. made this point in an address before the House Magazine Workshop.

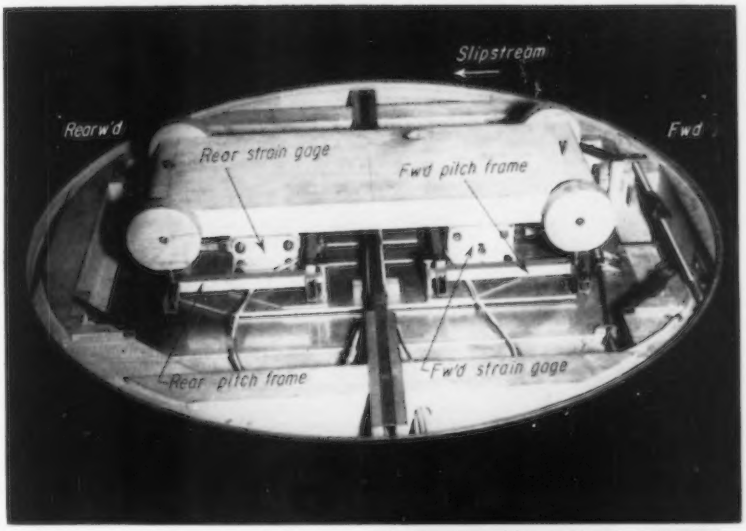
Too many company communication programs are based on what management thinks employes want to know or ought to know. But the traditional stream of words on Suzie's baby, the bowling league, and fringe benefits are received passively by most employes.

Employe curiosity about product development and company affairs has shown up in Savage-Lewis studies of attitudes in manufacturing, trade and service industries.

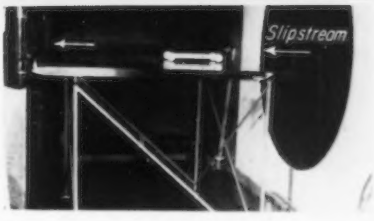
Management reaction to these studies, Mr. Dobson says, is often "so what." It feels that passing information along to employes may limit management's freedom of action without producing more loyal employes.

Mr. Dobson counters management apathy with another Savage-Lewis study—this one of 4000 white-and blue-collar workers in three firms. The study indicated that employes who knew more about their company spoke of it more often and more favorably to friends and neighbors.

Employes want to be treated as adults Mr. Dobson says. This precludes general use of a comic-book approach. And magazines and pamphlets are too slow. By the time they get to the employe he generally has some information—often incorrect.



Wind-tunnel gage . . . recessed in table top (see above) directly under model car measures aerodynamic forces acting on model.



Forces are transmitted . . . through bolts under each wheel (at right) to strain gages fastened to base plate.

New Wind-tunnel Gage Helps French Auto Designers

PARIS—French automakers are using a new scale to measure how aerodynamic forces affect automobiles. Renault, France's largest carmaker, has already modified its turbine-powered "Shooting Star" because of tests based on the new device.

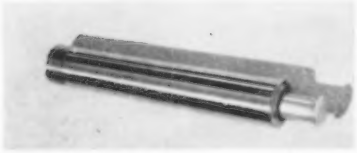
The gage was designed by Eiffel Laboratories, Paris, to calculate drag, pitch moments, lift, gyration, and difficult-to-measure skid drag. Development of the nonfriction, or freely suspended gage has reduced design-analysis time by about 70%, according to the lab's director, Marcel Chabonap. Aerodynamic problems are relatively long and tedious. But now any body design can be completely evaluated in a day and a half, says Chabonap.

The device works this way: A miniature car model is attached by its wheels to four bolts on the scale, which is recessed into a table top that simulates a road surface.

When air flow starts, the model reacts through the four connecting bolts. These attach to cantilevered frames that are hooked strain gages. The gages transmit electrical impulses to a galvanometer.

The base plate supporting most of the mechanism can be swiveled so that the model does not face directly into the slipstream—the off-center readings provide skid characteristics.

READER TO EDITOR



The 19th Way

To the Editor:

In your Design Roundup Section (Nov 11, p. 123) you discuss "17 Ways to Positively Lock a Taper Pin." Are you unaware of the existence of a commercial product that could be considered the 18th and best way to install a taper pin? These taper pins have mechanically expanded annular rings on the small end and are driven by any blunt instrument such as a hammer. They may be obtained from: The Deutsch Fastener Corp., 14504 South Figueroa St. Gardena, Calif.

—W. T. Barker
Section Head, Equipment
North American Aviation, Inc.

• *The 18th way to lock taper pins was suggested by Mr. W. Yates Farnsworth (Jan 6, p 140). This is No. 19.*—Ed.

Car Overhaul

To the Editor:

Mr. Hugh Stewart's letter in the November 18th issue (about windshield wiper blades with obsolescence built-in) brings to mind a modification I have made on my car.

When my 1949 Ford 6 needed an overhaul, I found among other things the valve springs imbedded in sand which apparently came up the breather pipe. In addition to the overhaul, I made the following alterations:

1. Plugged the breather pipe.
2. Installed an oil filter (military standard type).
3. Installed an oil-filler cap containing a breather (with wire mesh filter and without a pipe running down to the road).
4. Installed an oil-bath air cleaner.

After making these alterations, I proceeded with the following:

1. Used best grade of low viscosity (or 10-30) motor oil.
2. Used cheapest grade of gasoline, white gas when available at a lower price, and occasionally some diesel fuel mixed with regular gasoline.
3. Cleaned and adjusted spark plugs and breaker points every 10,000 to 20,000 miles.
4. Cleaned carburetor occasionally (10,000 to 20,000 miles). Added acetone or proprietary carburetor cleaner (½ cup) followed by motor oil (1 cup) to a hot running engine through carburetor air intake every 2000 or 3000 miles, or when gas mileage dropped.
5. Removed dirt accumulation from oil filter whenever oil began to get dirty, or after going through dust or sand storms. In addition, changed oil filter element whenever it appeared very dirty.
6. Changed oil at 20,000 to 40,000 miles (although it did not seem to need it).
7. Did not drain transmission (manual type) or differential, but checked quantity and quality (by appearance and feel) of lubricant.

The engine was in excellent condition when the car was sold after 70,000 miles of this treatment—total mileage was 120,000 miles.

My 1955 Chevrolet 6 has gone 50,000 miles, been driven through many dust and sand storms and it is in excellent condition.

—Kenneth Kahn
Hollywood, Calif.

• *Automotive marketing people seem to have pretty good evidence that most of us buy style rather than transportation—even though it is a major investment (see "Motivation Research," Jan 13 '58, p 38). If car buyers ever decided they really wanted transportation, the demand certainly would have a large impact on the auto industry and all its suppliers.*—Ed.

Societies Should Merge Their Interests

To the Editor:

Your editorial, "Why Aren't Engineers Recognized?" (Dec. 9, p. 71) is certainly an excellent and succinct summary of the situation. You are doing the engineering profession a great service. In this connection, I believe the American Institute of Electrical Engineers has now established, as a matter of policy, the conclusions which you state in the last paragraph of your editorial. I trust all engineering societies will merge their common professional interests to achieve the desired end of raising engineering to the status of an established profession.

—Prof. Pierre M. Honnell
Washington University
St. Louis, Mo.

Tons, Not Pounds

To the Editor:

We have studied your article describing our power gas locomotive. (Sept. 16, p. 92). We are sorry to state that in the diagram giving effort at the driving wheels versus speed you have given the tractive effort in lb x 1000 instead of kg x 1000 (or tons), which makes the black curve show a tractive effort less than half the real one over the whole speed range.—Aktiebolaget Gotaverken
Goteborg, Sweden

Caught With Our Doors Down

To the Editor:

Flexible rubber doors (Dec. 16, p. 19) are neither new nor French. As originator of this type of door the writer first introduced them in The Netherlands and England around 1940 and obtained US patent in 1942. After World War II the Candor Engineering Co. of Montclair, N. J., was organized and in 1946 the manufacture of rubber doors in this country was started. Since that time over a thousand Candor doors have been installed.

Most of the rubber doors made outside the US are copies of Candor doors. Ours are not limited to the sizes of your French source, but are made up to 10 ft wide and 12 ft high.

—Edward Cann, President
Candor Engineering Co.
Upper Montclair, N. J.

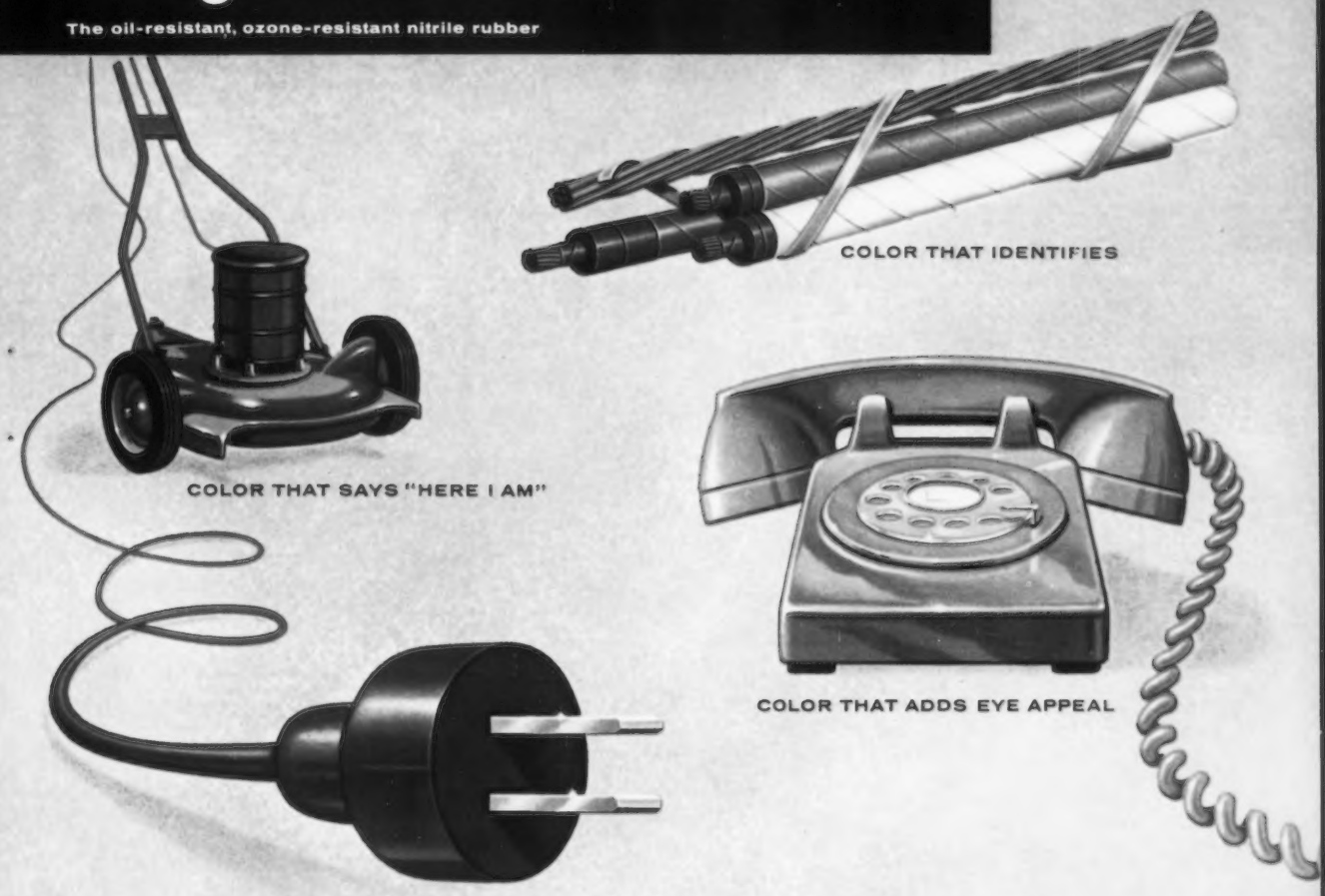
To the Editor:

We are a copper mining operation on the northern tip of Michigan's Upper Peninsula and consequently the winter months present the problem of ice forming in our inclined mine shafts. To date, we have used doors operated by manpower so you can realize our interest in the rubber doors. Are there any manufacturers in the US?

—J. F. Viola
Calumet & Hecla, Inc.
Calumet, Mich.

Naugatuck PARACRIL OZO

The oil-resistant, ozone-resistant nitrile rubber



COLOR THAT IDENTIFIES

COLOR THAT SAYS "HERE I AM"

COLOR THAT ADDS EYE APPEAL

Now! lasting COLORS in rubber wire jackets

A development of Naugatuck research makes it possible to combine in a vulcanized rubber wire jacket all these properties:

- Excellent resistance to ozone and outdoor "weathering"
- Outstanding heat resistance
- High abrasion resistance
- Excellent oil, grease and chemical resistance
- Fast CV extrusion

...PLUS PERMANENT BRIGHT COLORS

In addition to the suggested uses, you will think of dozens of other applications where wire jacketing with all these properties can serve either an aesthetic or utilitarian purpose.

One of Naugatuck's technical representatives will be happy to discuss with any prospective user the formulation of the Paracril® Ozo compound which makes possible this combination of properties... not only in wire jacketing but also in shoe soles, hose jackets, weather stripping and other vulcanized rubber products.

Naugatuck Chemical

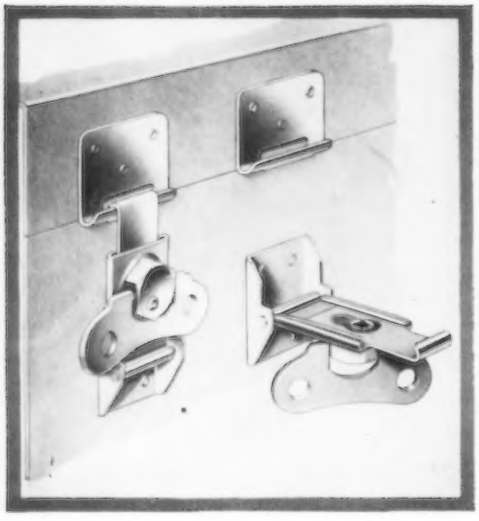
Division of United States Rubber Company, Naugatuck, Connecticut

Rubber Chemicals · Synthetic Rubber · Plastics · Agricultural Chemicals · Reclaimed Rubber · Latices · **CANADA:** Naugatuck Chemicals Division, Dominion Rubber Co., Ltd., Elmira, Ontario · **CABLE:** Rubexport, N.Y.

Note—Commercial and Military Packaging Engineers:

Rugged LINK-LOCK

...your best answer to exacting closure problems



Photograph courtesy of Craig Systems, Inc.

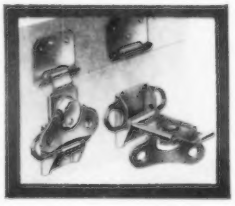
LINK-LOCK provides pressure-tight closure on this rigidly specified equipment container

Simmons LINK-LOCK provides quick opening and closing as well as impact-resistant dependability on transit cases manufactured by Craig Systems, Inc., Danvers, Mass.

The cylindrical Craig container above is gasketed and pressure-tight, and contains delicate electronic equipment. Twelve LINK-LOCK fasteners are used on this model.

Here's why LINK-LOCK is ideal for use on military cases produced to exacting specifications as well as on inexpensive commercial containers:

- Impact and shock resistant (positive-locking).
- High closing pressure with light operating torque..... insures pressure-tight seals where required.
- Available in 3 sizes, for heavy, medium, and light duty.
- Compact design...lies flat against case even when unlocked.
- Opening and closing by wing-nut, screwhead, or hex nut.
- Flexible engagement latch design...can be varied to suit different conditions.



Also available: Spring-Loaded LINK-LOCK. Ideal for the less expensive containers where costs won't permit precision production. Spring provides take-up to compensate for set in gasketing, irregularities of sealing surfaces, and mounting inaccuracies.

Where does the versatile Simmons LINK-LOCK belong in your design? For complete information and specifications, send for the Simmons Catalog today. Samples and engineering service available upon request.

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See our 8 page catalog in Sweet's 1958 Product Design File

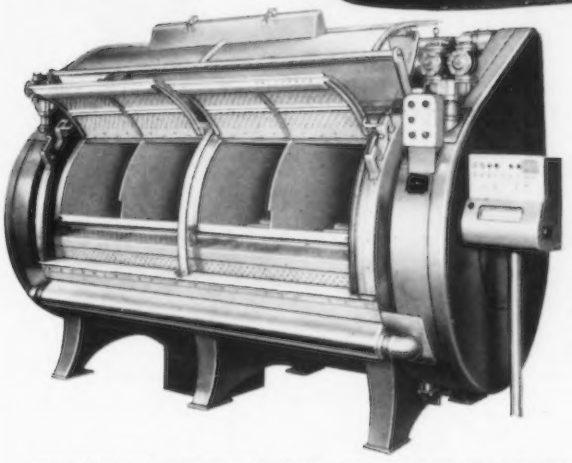
CUTLER-HAMMER

MOTOR CONTROL

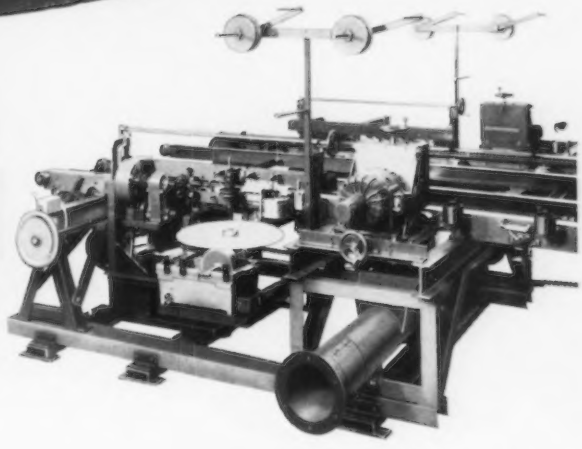
C-H

CHOICE OF THE LEADERS

THE MARK OF BETTER MACHINES

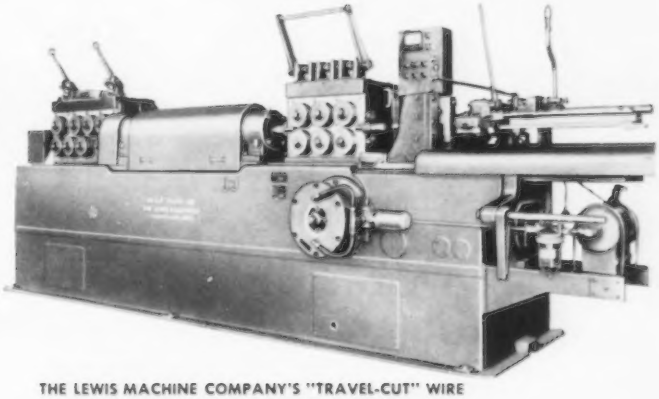


THE 1,500 LB. "MASTER" MANUFACTURED BY THE MILLER LAUNDRY MACHINERY COMPANY; DETROIT, MICHIGAN; INCLUDES CUTLER-HAMMER CONTROL AS STANDARD EQUIPMENT.



THE HIGH SPEED WALLBOARD SAW AND EDGE STRIPPER BUILT BY THE BRACKETT STRIPPING MACHINE CO. IS EQUIPPED WITH CUTLER-HAMMER MOTOR CONTROL.

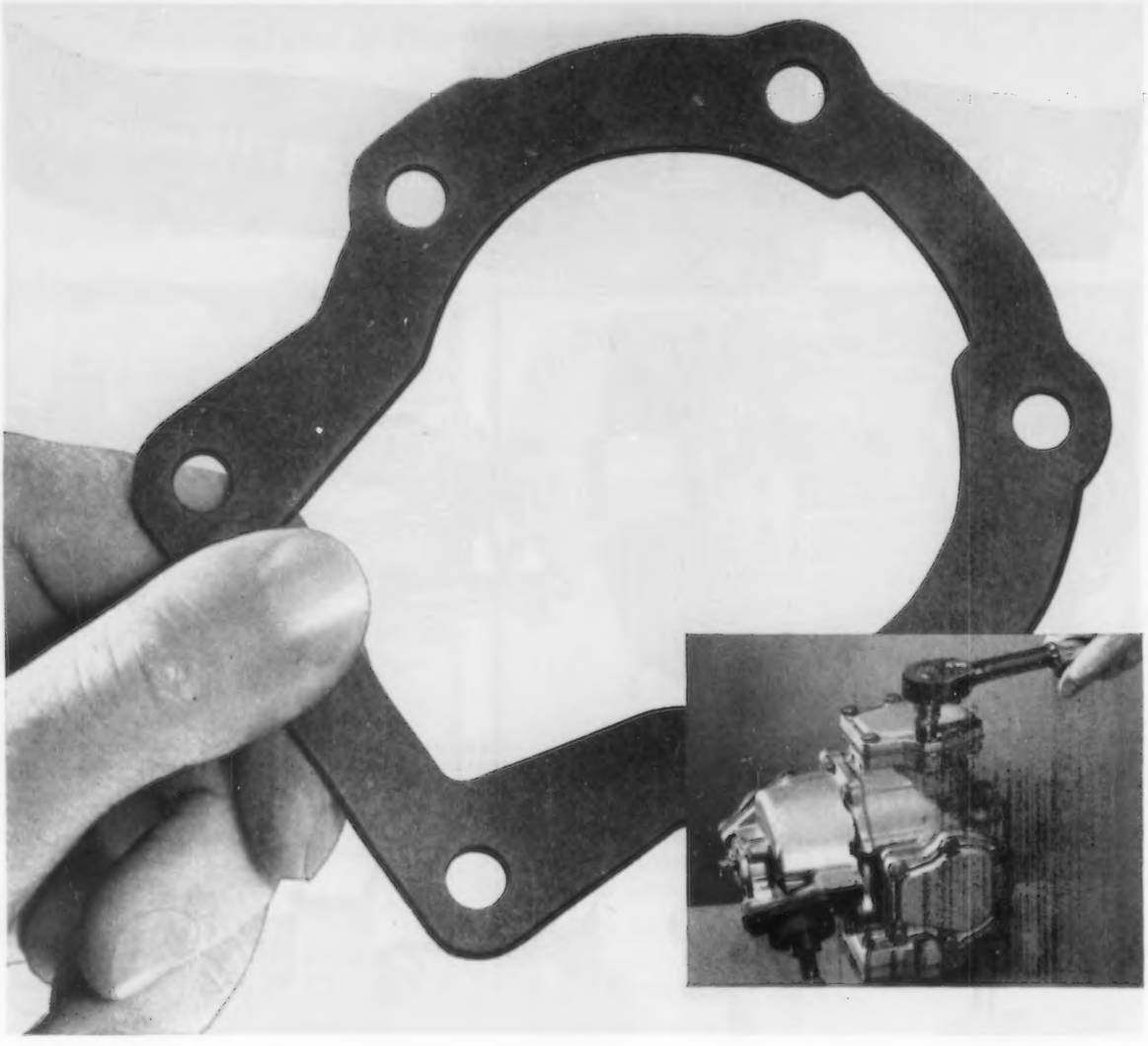
BOTH THE WALKER-TURNER AND DELTA POWER TOOL DIVISIONS OF THE ROCKWELL MANUFACTURING COMPANY INCLUDE CUTLER-HAMMER CONTROL COMPONENTS AS STANDARD EQUIPMENT ON THEIR MACHINES.



THE LEWIS MACHINE COMPANY'S "TRAVEL-CUT" WIRE STRAIGHTENING AND CUTTING MACHINE USES CUTLER-HAMMER THREE-STAR MOTOR CONTROL AND HEAVY DUTY OIL-TIGHT PUSHBUTTONS.

Preference For The Stars

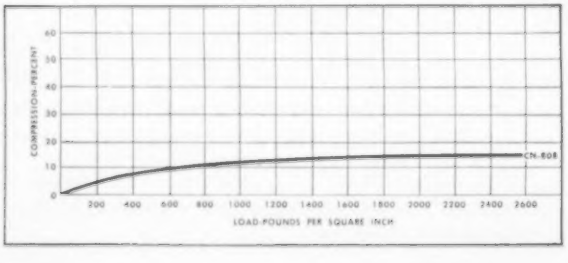
Among the numerous manufacturers of every type of machine made there are always a certain few who are recognized as leaders. These leaders have won success because of the excellence of their product. Basic to such excellence is sound engineering, and sound engineering invariably means the utmost discrimination in the selection of components for inclusion on their machine. Able engineers respect able engineering. And for this reason Cutler-Hammer Three-Star Motor Control and Control Accessories are so frequently the repeated choice of the leaders, and the mark of better machines. CUTLER-HAMMER Inc., 1332 St. Paul Avenue, Milwaukee 1, Wisconsin. Associate: Canadian Cutler-Hammer Ltd., Toronto.



Pre-compressed fiber gasket seals lightweight castings at low flange pressure

Armstrong Accopac® CN-808 is particularly recommended for sealing lightweight flanges, such as the light casting used in this gasoline pump metering unit.

With CN-808, there is no danger of flange distortion. You get an effective seal at bolting pressures lower than with any other fiber gasket material—as low as 800 psi. That's because CN-808 is a pre-compressed material.



Very little of the bolt torque is used to close the interstices normally found in fiber sheets.

CN-808 is made by the patented Armstrong beater-saturation process, in which cellulose fibers and finely ground cork are combined with a non-volatile latex binder. As a result, it has great crush resistance, plus excellent dimensional stability. The special nitrile-type (Buna-N) binder makes CN-808 suitable for sealing gasoline, light petroleum distillates, or water services.

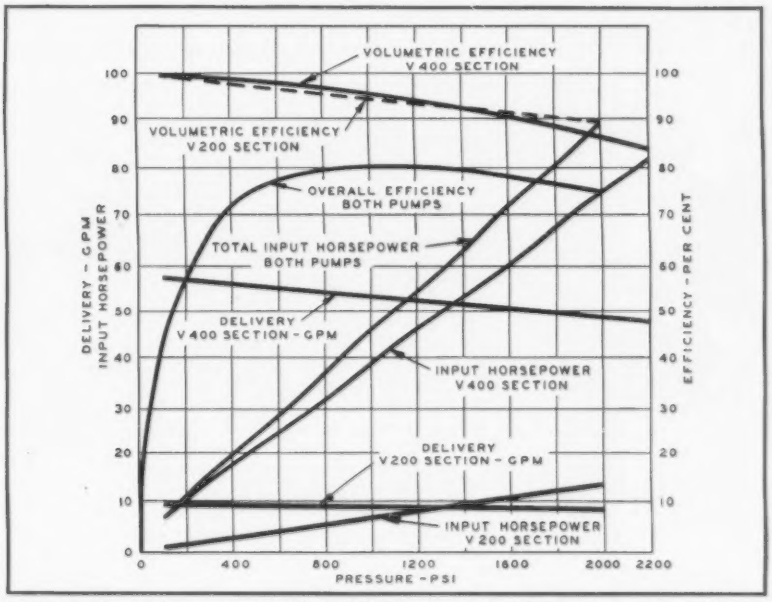
For more information on Accopac materials, write Armstrong Cork Company, Industrial Division, 7002 Irvin Street, Lancaster, Pennsylvania.

Armstrong ACCOPAC

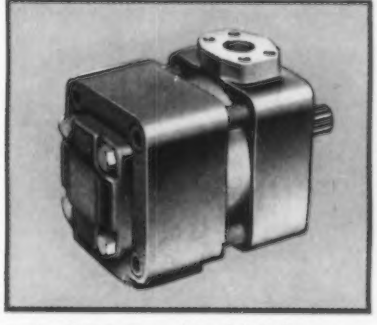
. . . used wherever performance counts

On tractor shovels, scrapers, lift trucks, truck cranes, bulldozers, motor graders, front end loaders, ditchers, trucks, buses and many other types of mobile equipment . . .

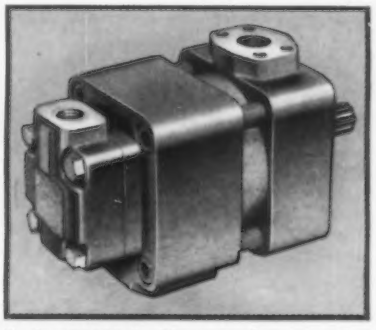
The *High Efficiency* of Vickers Balanced Vane Pumps Means *More* Work From *Less* Input Power


VOLUMETRIC EFFICIENCY V400 SECTION
VOLUMETRIC EFFICIENCY V200 SECTION
OVERALL EFFICIENCY BOTH PUMPS
TOTAL INPUT HORSEPOWER BOTH PUMPS
DELIVERY V400 SECTION - GPM
INPUT HORSEPOWER V400 SECTION
DELIVERY V200 SECTION - GPM
INPUT HORSEPOWER V200 SECTION
DELIVERY - GPM INPUT HORSEPOWER
EFFICIENCY - PER CENT
PRESSURE - PSI
0 400 800 1200 1600 2000 2200
0 10 20 30 40 50 60 70 80 90 100

COMPARE the performance of this VICKERS Series V4200 double pump with any other hydraulic pump used on mobile equipment. The high overall efficiency in the operating pressure range is maintained throughout the long pump life (see right hand column for reasons). This performance is characteristic of all Vickers Vane Pumps . . . both single and double. (Above curves are in accordance with SAE test code except speed is 2000 rpm.)



Series V400 pump (single) is large section of double pump at right; performance characteristics are shown above. In addition to the advantages mentioned in the right hand column, Vickers Vane Pumps require minimum maintenance and are exceptionally compact. Their various mountings and optional pressure outlet connection positions provide greater application versatility. See pages 4-5, Bulletin M5101A.



Series V4200 double pump for operating two independent hydraulic circuits from one power source. In numerous mobile applications, this is desirable to eliminate all possible chance of one operation interfering with another . . . when necessary to operate two machine components simultaneously at different speeds and hydraulic pressures. See pages 6-7, Bulletin M5101A.

You can get more useful work out of a given engine when a Vickers Balanced Vane Pump is used in the hydraulic control system. Its exceptionally high volumetric and overall efficiency are available not only when the pump is new but also throughout its long life.

The performance curves at the left merit your careful consideration. Note that the overall efficiency is approximately 80% at operating pressures used. Compare this with the rapid decline in overall efficiency of the usual gear pump at higher pressures. This large difference means a very substantial saving in engine horsepower and fuel consumption. To do a given job, it often means that a smaller engine can be used. It further means less heating of the oil.

Vickers Balanced Vane Pumps have many other benefits for the user. Optimum running clearances are automatically maintained over the entire operating pressure range and throughout an exceptionally long pump life. Complete hydraulic balance eliminates pressure-induced bearing loads. Other bonuses are: automatic wear compensation, temperature adaptability, simple installation, and easier cold weather starting.

Millions of Vickers Vane Pumps are in daily use. For further information, write for Bulletin M5101A.

7856

VICKERS INCORPORATED
DIVISION OF SPERRY RAND CORPORATION
Mobile Hydraulics Division
ADMINISTRATIVE and ENGINEERING CENTER
Department 1454 • Detroit 32, Michigan

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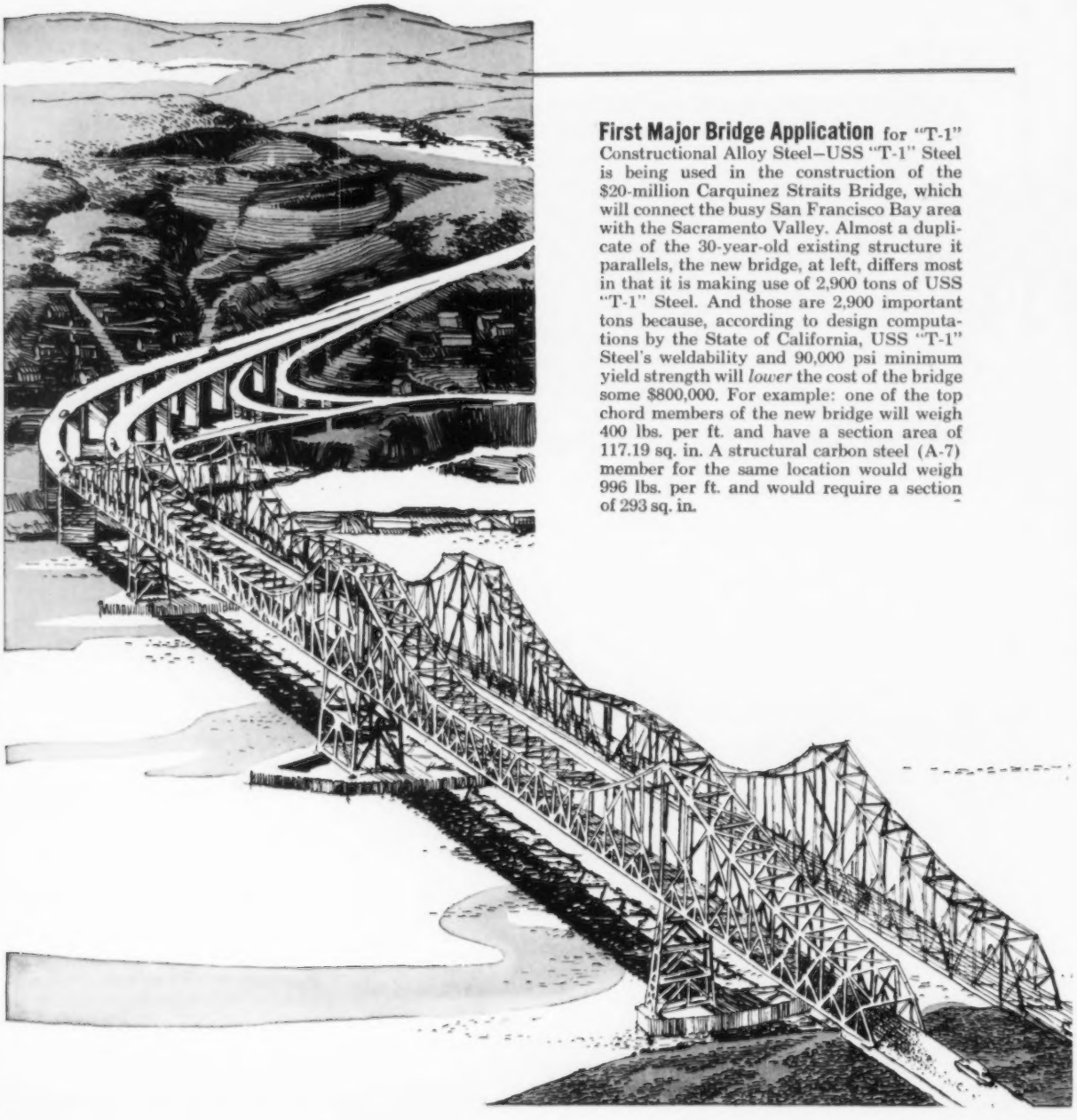
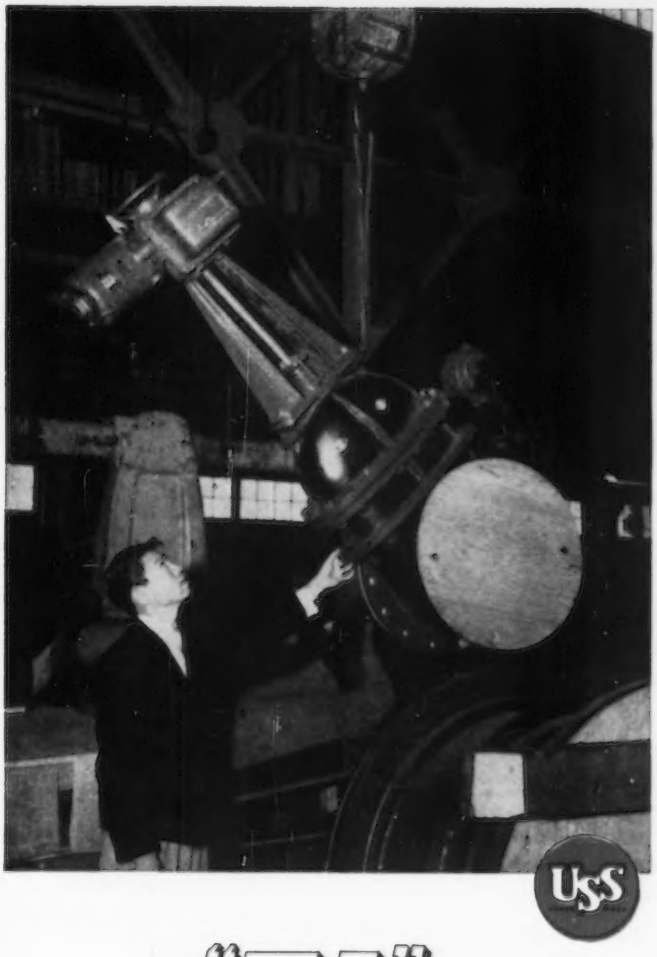
In Canada: Vickers-Sperry of Canada, Ltd., Toronto & Montreal

HOW USS "T-1" STEEL IMPROVES THESE PRODUCTS:



First Major Bridge Application for "T-1" Constructional Alloy Steel—USS "T-1" Steel is being used in the construction of the $20-million Carquinez Straits Bridge, which will connect the busy San Francisco Bay area with the Sacramento Valley. Almost a duplicate of the 30-year-old existing structure it parallels, the new bridge, at left, differs most in that it is making use of 2,900 tons of USS "T-1" Steel. And those are 2,900 important tons because, according to design computations by the State of California, USS "T-1" Steel's weldability and 90,000 psi minimum yield strength will *lower* the cost of the bridge some $800,000. For example: one of the top chord members of the new bridge will weigh 400 lbs. per ft. and have a section area of 117.19 sq. in. A structural carbon steel (A-7) member for the same location would weigh 996 lbs. per ft. and would require a section of 293 sq. in.



At Home In A Crowd. That's USS "T-1" Steel. It's really at home in this, the crowd rack of the world's largest power shovel. Built by Marion Power Shovel Company, the big digger is in service for Hanna Coal Company. Operating around the clock, winter included, the crowd rack must withstand constant, brutal impact loading, often in sub-freezing temperatures. USS "T-1" Steel (also used in the dipper, dipper stick and bail) supplies the strength, toughness, and resistance to impact abuse so critically needed.

Fabri-Valve Fabricates Faster For Less. The Fabri-Valve Company of America fabricates valves as opposed to casting them. A recent job for the U.S. Air Force called for 2 types of electric-motor-operated wedge-gate valves, subject to temperatures from well below zero up to 300° F., and pressures of 37.5 psi absolute plus a shock load of 200 psig. By using USS "T-1" Steel for the majority of the valve parts, Fabri-Valve pared off 25% of the time and expense normally required to fabricate the valves. Quoting the Company's Vice President, "USS 'T-1' Steel was chosen for its toughness, impact strength, its quality of handling low temperature applications. Very important, too, is its ready weldability and fabricability. USS 'T-1' Steel's yield strength of 90,000 psi helped reduce thickness, thereby reducing cost."

HOW IT CAN HELP YOU

USS "T-1" Steel, with its high minimum yield strength of 90,000 psi and its minimum tensile strength of 105,000 psi, can help you design or build lighter-weight equipment that will last longer. Its unusual toughness can help you design or build equipment capable of taking severe impact and abuse at sub-zero temperatures. Its weldability can help you cut the cost of fabricating highly stressed parts, and reduce repair and maintenance expense. Its good creep rupture strength can help you put more durability in equipment that operates at temperatures as high as 900 degrees F.

Somewhere in your operation, versatile USS "T-1" Steel can help you. Write, wire, or phone United States Steel, Pittsburgh 30, Pa.

USS "T-1" CONSTRUCTIONAL ALLOY STEEL

"USS" and "T-1" are registered trademarks

United States Steel Corporation, Pittsburgh • Columbia-Geneva Steel Division, San Francisco • Tennessee Coal & Iron Division, Fairfield, Ala.
United States Steel Supply Division, Warehouse Distributors, Coast-to-Coast • United States Steel Export Company, New York

UNITED STATES STEEL

HEIM *Unibal*® Rod Ends

...in good company...

The new General Electric J79 jet engine has the highest thrust-to-weight ratio of any aircraft power plant in production. The engine is rated in the 10,000-pound thrust class.

Variable stators are used for the first time in a flying jet engine, which in a mechanically simplified way, and with far less weight, accomplish the same thing that the dual rotor does in other current engines. The device provides a smooth flow of air inside the engine and eliminates the "stall barrier" problem.

HEIM UNIBAL SPHERICAL BEARINGS and ROD ENDS supply the exact type of linkage, mounting, and degree of misalignment correction required by this engine, and The Heim Company is proud of its contribution to the success of the GE J79.

There are over 200 Unibal Rod Ends assembled with the variable pitch stator blade operating levers.

There are over 50 LS type Unibal Spherical Bearings used as pivot points for the inlet guide vanes.

The bearings which mount the engine to the airframe are three Heim Unibal cartridge units. These bearings carry the entire weight of the engine *and its thrust*.

Other Heim bearings of various types used on this engine bring the total to around 500.

* * * *

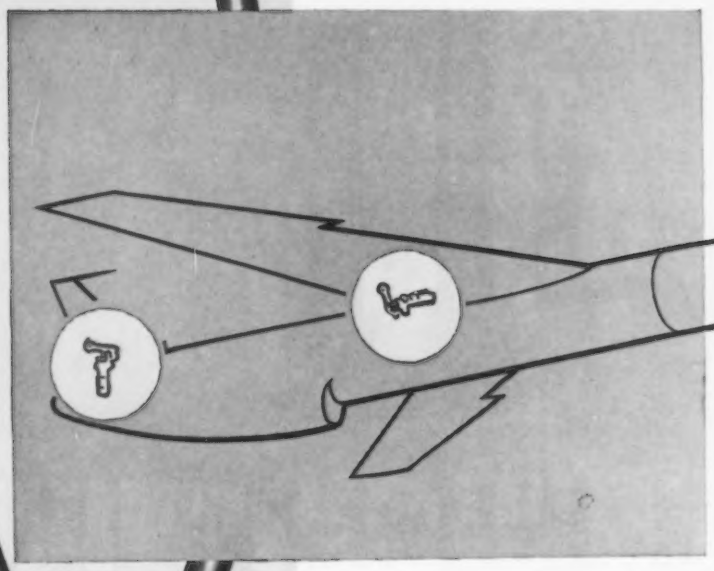
The load carrying capacity of Unibal spherical bearings is very high. They are applicable in any linkage where motion must be transmitted at constant or varying angles. They are ideal as supports to any device which is subject to mechanical or thermal deflection.

COMPLETE CATALOG AVAILABLE / SOLD THROUGH THE LEADING BEARING DISTRIBUTORS

THE HEIM COMPANY, FAIRFIELD, CONNECTICUT

. . . To blast an INVADER . . . .

LINEAR KEEPS THE "GO" IN PROTECTIVE MISSILES with Jet-Age "O" Rings



Modern warfare weapons . . . that guard and protect . . . are highly complex devices. They must be dependable for instantaneous service—even after an unpredictable shelf-life.

In rocket and missile warfare use, "O" rings will be subjected to nitrogen, JP-4, ethylene oxide, hydrogen-peroxide, alcohol, liquid oxygen, fuming nitric acid, and other destructive environments. "O" rings are used in the servo-systems for flight control of guided missiles, and must withstand extremes in temperatures and the destructive actions of synthetic fluids.

LINEAR's experience in the design and production of precision "O" rings —of the most modern elastomers—has given them the ability to provide dependable seals for the most critical requirements.

When it's a sealing problem, call on LINEAR or one of its agents for engineering assistance . . .

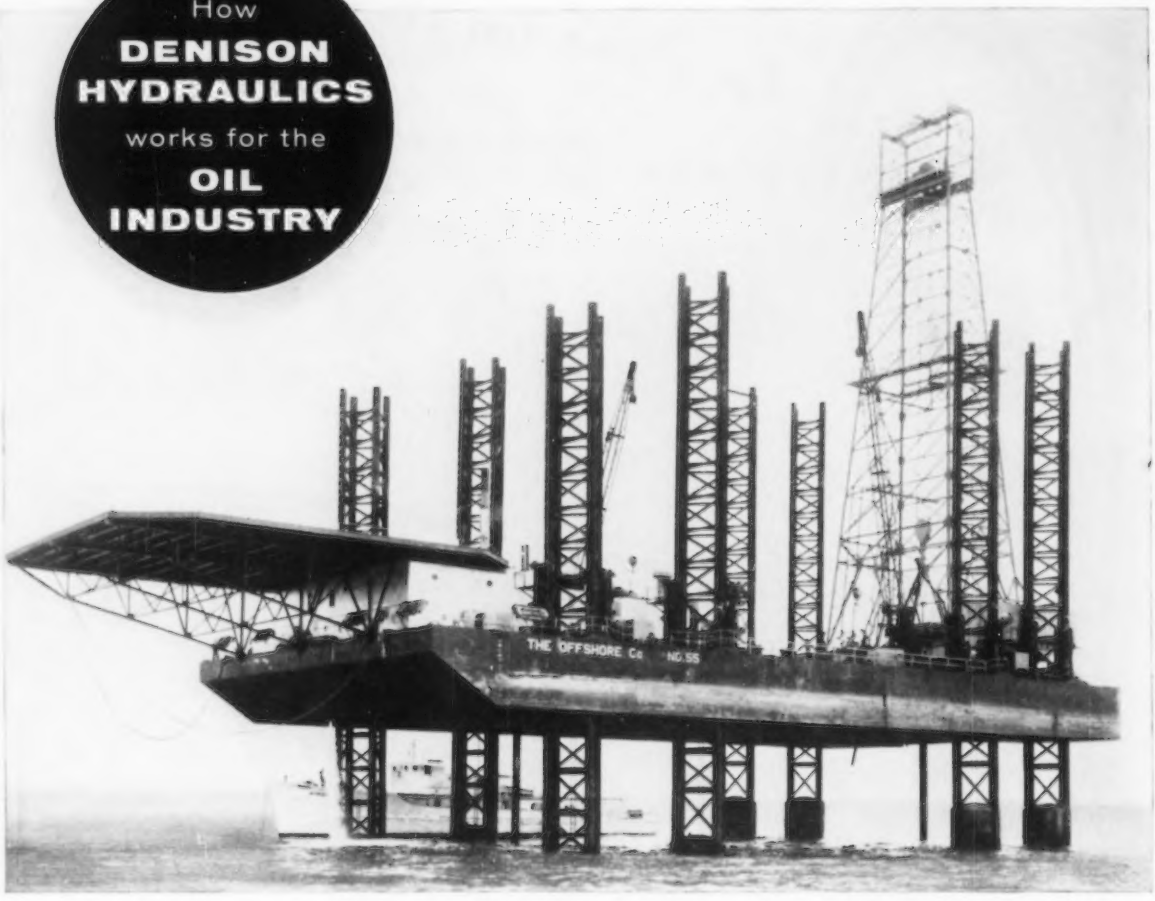
and be sure to specify LINEAR "O" Rings for prototype or production.

"PERFECTION IN RUBBER"

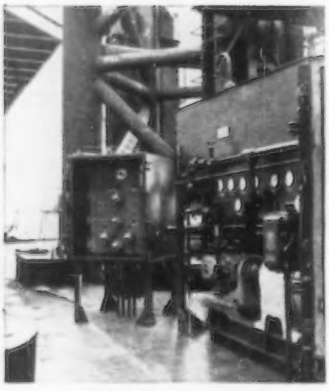
LINEAR

LINEAR, Inc., STATE ROAD & LEVICK ST., PHILA. 35, PA.

How
DENISON HYDRAULICS
works for the
OIL INDUSTRY



Lifts 6000 tons out of the sea with
DENISON HYDRAULIC PUMPS



***Actuating System Controls** for raising and lowering heavy off-shore rigs built by DeLong Corporation, New York. Denison axial piston pumps actuate hydraulic jacking cylinders, separately or in unison.*

When The Offshore Company faces the problem of raising its 6000-ton DeLong drill barges, they rely on Denison axial piston pumps to deliver the necessary muscle. Rated at 5000 psi continuous duty, four Denison pumps lift the 6000-ton platform at rates up to 15 feet per hour . . . with precision control from one central source.

Utilizing a Series 800, 35 gpm Denison pump at each corner, the hydraulic system developed by DeLong and built to specifications by Denison is capable of actuating lifting jack cylinders separately or in concert as needed. The result is close regulation of the massive 6000-ton load through a system of 16 individual hydraulic jacks on 8 caissons or towers.

Whatever your actuating problem, Denison can help you develop an efficient hydraulic system to do the job dependably and at low cost. Why not consult Denison on your next job. No obligation. Write us. Denison Engineering Division, American Brake Shoe Co., 1194 Dublin Road, Columbus 16, Ohio.

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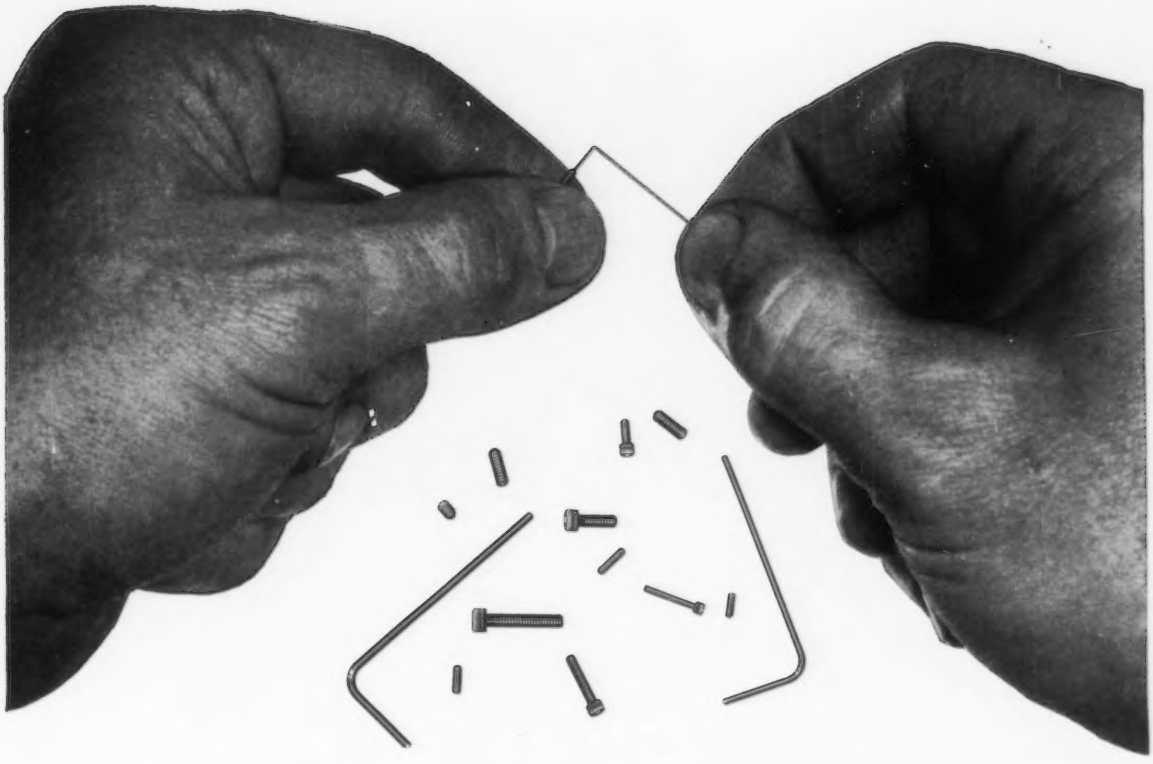
DENISON HydrOILics

HYDRAULIC PRESSES • PUMPS • MOTORS • CONTROLS



If you're miniaturizing . . . you'll save space, time and money with Allen Minicaps and Minisets (#0 thru #3 dia.)

These miniature Allen Hex Socket Cap and Set Screws will let you scale down your product sizes even farther. They're made from Allenoy special alloy steel — so strong that you can safely specify fewer screws or smaller sizes.

Allen Minicaps and Minisets are tiny, but very tough! — true Allens, with deep, clean, strong sockets and uniform Class 3A threads. Minicaps have the Allen knurled "Grip-Head" and are trimmed both on top and *under* the head, for tighter fit and better appearance. Minisets have the improved small-cup Allenpoint that drives deeper and holds tighter.

Because sockets are uniformly true hexagon shape, the key or driver fits tight — makes starting much easier, saves a lot of time in assembly.

Diameters of these miniatures run from #0 through #3. Minicap lengths run from ⅛" through ½", and Miniset lengths from 1/16" through ¼". Also standard in stainless steel. Your Industrial Distributor has them now. He'll show you why these Allens — like all Allens — hold tighter and last longer. Or write for information and samples.

Use Minicaps and Minisets wherever you need dependable fastening in very small assemblies:

TV, radio and telephone equipment • Guided missiles, rockets • Panel meters • Electro-mechanical devices and servo-systems • Computers • Control and operating mechanisms for relays • Cameras • Instruments

Stocked and sold by leading industrial distributors everywhere

ALLEN MANUFACTURING COMPANY
Hartford 2, Connecticut, U.S.A.

ALLEN HEX-SOCKET SCREWS HEAD

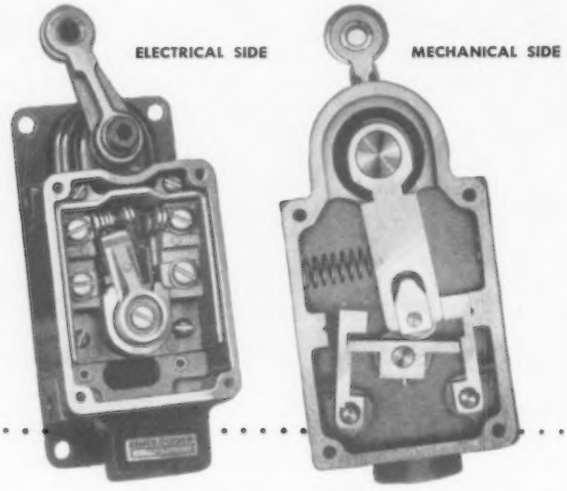
PROVED . . . by millions of contacts

NATIONAL ACME
SNAP-LOCK
TRADE MARK

As illustrated below, National Acme SNAP-LOCK Limit Switches employ a basically simple yet positive *snap-action* locking mechanism—with extremely few moving parts. Thus wear is reduced to a minimum and dependable trouble-free service, far beyond normal limits, is assured.

The double-throw contact lever, connected directly by shaft with the latch bar, carries self-wiping coin silver contact points to assure quick action make or break—reducing wear ever further.

Electrical and mechanical sides are separated by a wall within a sturdy die-cast housing which is fully insulated and is dust and oil-tight.



THE ORIGINAL SNAP-ACTION LOCKING SWITCH

SNAP-LOCK LIMIT SWITCHES. Made in single-pole and double-pole series, in four types: Standard, Short Travel, Neutral Position and Push Lever. With the exception of the Push Lever Switch, all are adaptable to special enclosures for hazardous location service and may be used with various styles of operating levers. For AC or DC service.

and now . . .

a new design concept for **CONTROL STATION SWITCHES**
the heavy-duty . . . oil, water, dust tight **GOLD-N-RING**
made by machine tool builders to machine tool specifications

Heavy duty silver-alloy contact points provide maximum electrical capacity, long life.
Heavy duty terminal screws have ¾" thread contact to prevent stripping during installation and permanently secure wires for continuous, trouble-free service.
Single or double-pole contact block assemblies—can be used interchangeably with several types of GOLD-N-RING push button and selector operator heads.
Rated for 600 volts—AC or DC. Meets all Joint Industry Committee and National Machine Tool Builder's Association requirements.
Protected against oil and water seepage in operator head by Sealtight oil-resistant rubber diaphragm.
Easily replaces existing switches.

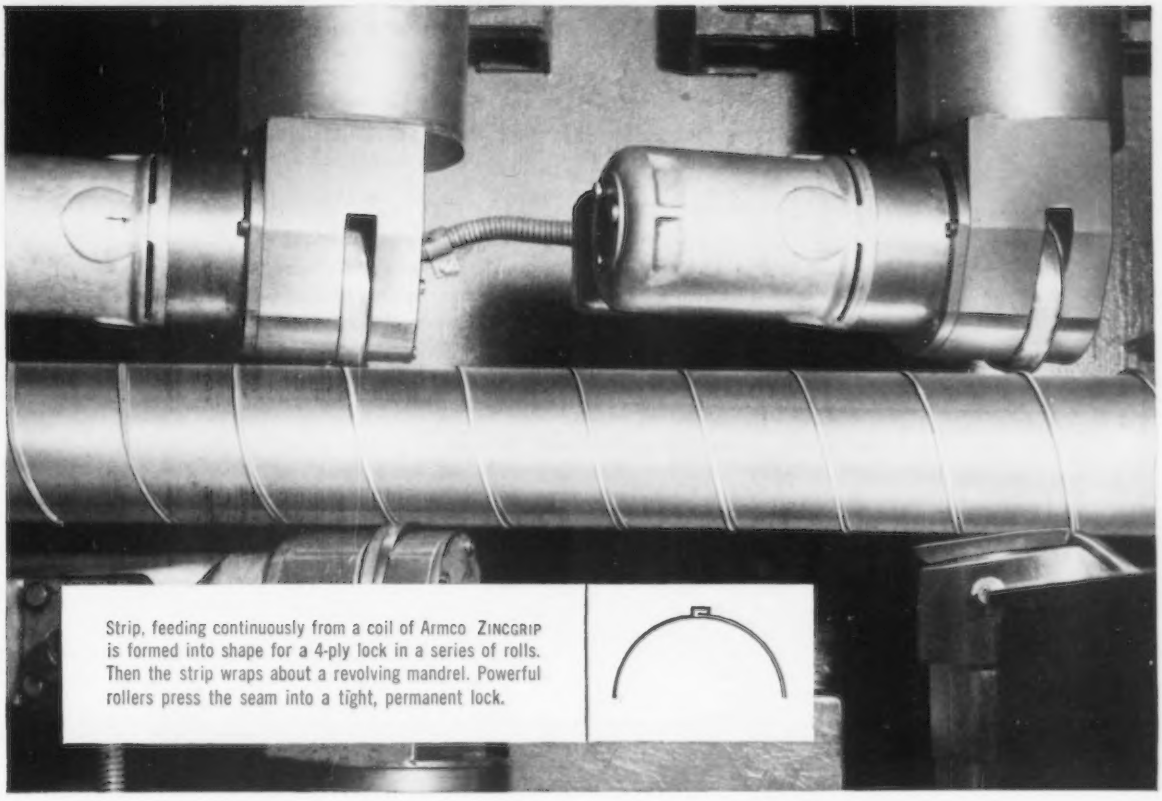
ELECTRICAL MANUFACTURING DIVISION

the National Acme company

170 EAST 131st STREET, CLEVELAND 8, OHIO

in this continuous lockseaming operation . . .

Zinc coating on Armco ZINCGRIP Steel doesn't flake or peel



Strip, feeding continuously from a coil of Armco ZINCGRIP is formed into shape for a 4-ply lock in a series of rolls. Then the strip wraps about a revolving mandrel. Powerful rollers press the seam into a tight, permanent lock.

Here's in-shop evidence that the zinc coating on Armco ZINCGRIP® Steel clings tightly during severe fabrication.

This machine forms sheet metal into conduit with a continuous spiral lockseam. Few fabricating operations could provide so severe a test for a zinc-coated steel. But Armco ZINCGRIP Steel meets every requirement. Its special hot-dip zinc coating doesn't flake or peel.

This complete zinc protection is doubly important for the conduit. It not only wards off rust when exposed on construction sites, but resists corrosion in areas within buildings where maintenance is difficult or impossible.

If your products require drawing, forming, lockseaming, or any other severe fabrication, you can rely on Armco ZINCGRIP. Just fill in and mail the coupon for full information about this workable, zinc-protected steel.

Other Armco Steels for top-quality products include ZINCGRIP PAINTGRIP®, Stainless Steels, ALUMINIZED STEEL, Cold-Rolled PAINTGRIP, Enameling Iron, Steel Tubing, Electrical Steels, High Strength Steels, Long Ternes, and high-quality Hot- and Cold-Rolled Sheets.

ARMCO STEEL CORPORATION
1348 Curtis Street, Middletown, Ohio

SEND complete information about Armco ZINCGRIP.

Name_____ Title_____

Firm_____

Street_____

City_____ Zone_____ State_____

ARMCO STEEL

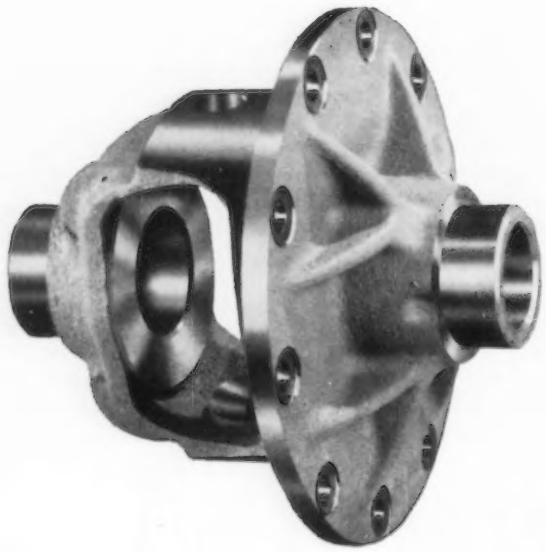
ARMCO STEEL CORPORATION • 1348 CURTIS STREET, MIDDLETOWN, OHIO

SHEFFIELD DIVISION • ARMCO DRAINAGE & METAL PRODUCTS, INC. • THE ARMCO INTERNATIONAL CORPORATION

how ARMASTEEL wider scope of

NEW PRODUCT DESIGNS POSSIBLE . . . Due to their unusual physical properties, high machinability ratings, and wide latitude of design, ArmaSteel castings are replacing other materials in today's products. Being a casting material, ArmaSteel can be formed in shapes too complex for the forging process. With ArmaSteel castings, low draft angles, intricate coring, and close dimensional tolerances are possible. Less stock remains to be machined. High tensile strength, damping qualities, and other physical and chemical characteristics are also major factors in ArmaSteel's popularity among product design engineers.

ARMASTEEL IS A PEARLITIC MALLEABLE IRON, possessing many of the physical characteristics of forged low-carbon steel. Because of carbon nodules in the pearlite matrix, the machinability of ArmaSteel castings is 58% better than S.A.E. 1040 steel and compares favorably with S.A.E. 1112. ArmaSteel is produced in three ranges, with tensile strengths from 70,000 psi to 100,000 psi, yield strengths from 48,000 psi to 80,000 psi, and elongations (in 2") from 2% to 4%. Because of these excellent properties, and because it can be either sand cast or shell cast, ArmaSteel provides improved parts for many products, at the same time that it lowers costs. On these pages are two case histories of products that have benefited from ArmaSteel castings . . . perhaps your product can benefit too.

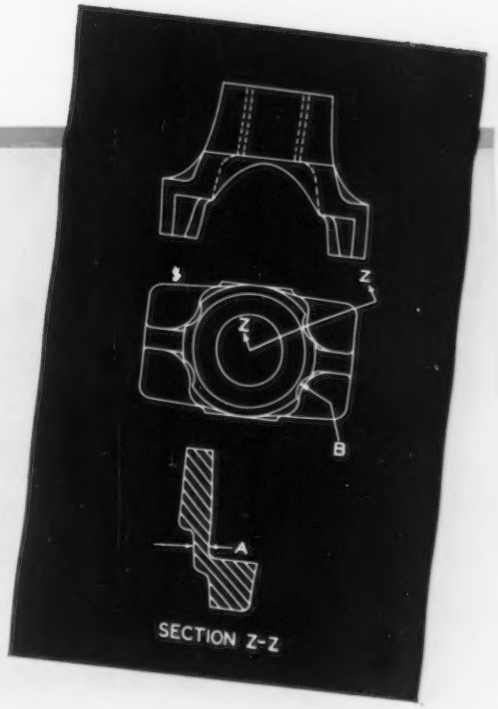


CAST ARMASTEEL IMPROVES AN AUTOMOBILE DIFFERENTIAL CASE

This case forms the support for the driving gears in an automobile. The demands made of such a part are that it be of high strength, that it have the least possible deflection, and that—because it is part of the car's unsprung weight—its weight be held to a minimum to help the riding characteristics. The part must be cast because it is impossible to forge the internal cavity.

ARMASTEEL 86M MET ALL THESE DEMANDS. It has a tensile strength of 70,000 psi, a yield strength of 48,000 psi, and a Brinell Hardness No. of 163-207. Deflection is very low, and ArmaSteel absorbs vibrant energy, thus contributing to quiet operation. The cast ArmaSteel part also allowed the manufacturer to eliminate thrust washers on the pinion gear bearings, reducing costs.

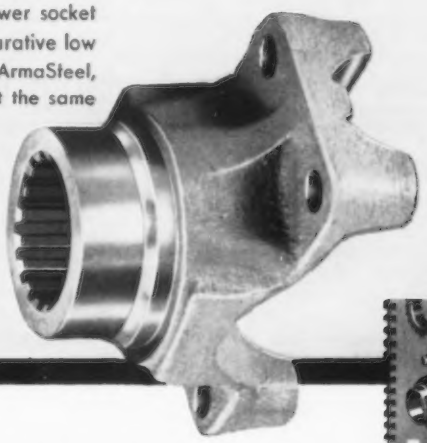
castings allow new and much design



CAST ARMASTEEL REPLACES FORGINGS IN THIS COMPANION FLANGE BECAUSE OF SPACE LIMITATIONS

This part was formerly a medium carbon steel forging. During a re-design of the unit, it was impossible to get the desired strength by enlarging the part, because of design limitations. It became apparent that the draft angles necessary in the forging would not allow proper thickness of metal at point "A". Only a casting could achieve the low draft angles needed, and only a high strength material could meet the design requirements.

CASTINGS OF ARMASTEEL 84M PROVIDED THE ANSWER. ArmaSteel 84M has an ultimate tensile strength of 100,000 psi, and a yield strength of 80,000 psi. ArmaSteel parts tested showed a long fatigue life and minimum deflection under the extreme stress involved. In addition, castings offered a reasonable cost per piece, excellent machinability, and uniformity in production lots. In broaching the spline in the center hole, the manufacturer found that ArmaSteel castings resulted in greatly improved broach life. Draft angles were reduced to 2°, which allowed sufficient clearance (point "B") for the power socket wrench assembly operations. Thus, due to the comparative low cost of castings and the reduced machining costs of ArmaSteel, the manufacturer enjoyed an overall saving and at the same time solved his design and assembly problems.



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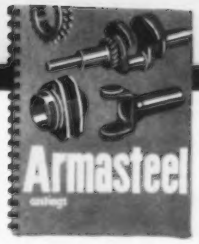


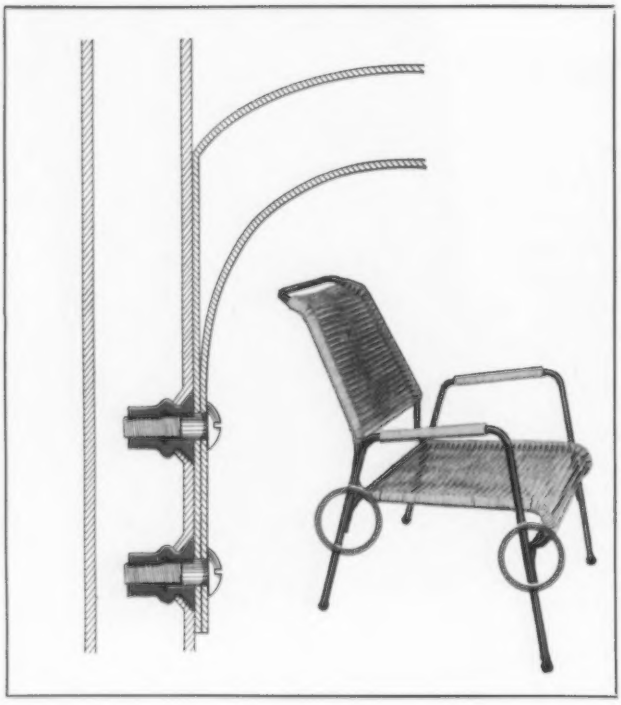
For further information on physical properties and applications of ArmaSteel, write for our complete catalog. Descriptive literature is also available on our shell mold and sand casting processes.

CENTRAL FOUNDRY DIVISION · GENERAL MOTORS CORPORATION

CENTRAL FOUNDRY DIVISION

GENERAL MOTORS CORPORATION • SAGINAW, MICHIGAN • DEPT. 10

Only B.F. Goodrich Rivnuts® give you firm, blind nutplates for tubular applications!



Finding a fastener that would preserve the clean, functional lines of their modern tubular furniture was a problem for the O. Ames Company. Stove bolts and screws projecting from the legs were not only unsightly, but were a major sales deterrent to a woman in 51 gauge nylons.

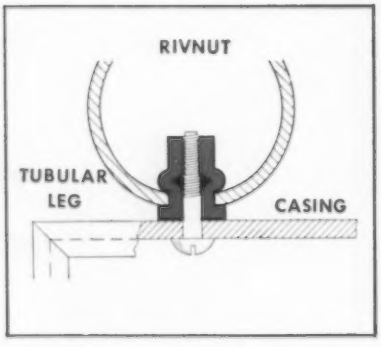
B. F. Goodrich Rivnuts provided the answer to this problem. Upset inside the tubular legs, Rivnuts with countersunk heads fit flush, take round headed attachment screws. In addition, Rivnuts hold firmly and permanently because the bulge in the Rivnut shank conforms to the curvature of the tube. Rivnuts are installed by one man in seconds, and provide an accurate nutplate for quick assembly of the finished product.

If you want to do a smoother fastening job, or are looking for ways to fasten faster and at less cost, use B. F. Goodrich Rivnuts.

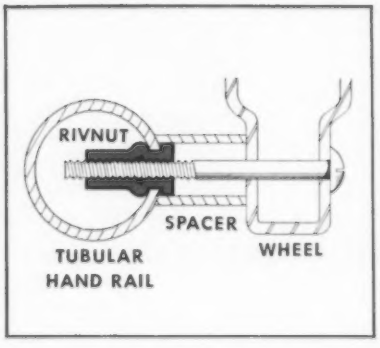
SEND NOW FOR FREE RIVNUT DEMONSTRATOR

Demonstrates with motion how Rivnuts fasten *to* and *with*. Explains construction, gives proved applications. Write to B. F. Goodrich Rivnuts, Dept. PE-28, Akron, Ohio.

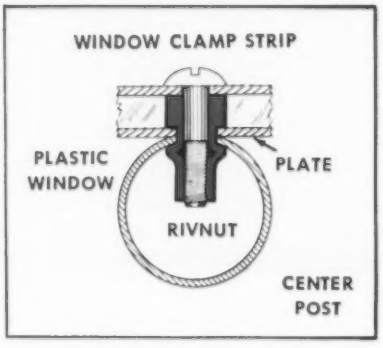
Rivnuts solve a variety of tubular fastening problems like these



Switching to Rivnuts speeded assembly of barbecues. One man installs a Rivnut in the tubular leg in seconds. There are no boltheads to detract from the unit's clean lines. Time is saved in faster knockdown for shipping.



Designers of a wheel chair needed a blind fastener with at least 6 clean threads to serve as a nutplate. Rivnut upset inside the tubular handrail of the wheel chair provides firm, accurate, nutplate for bolt attachment to the wheels.



Upset Rivnut secures airplane window plate to center post. Firm bulge in shank seals weather out. Rivnut head serves as spacer for plastic window, while 6 clean threads hold clamp strip and window securely in place.

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NEW, IMPROVED HAMILTON

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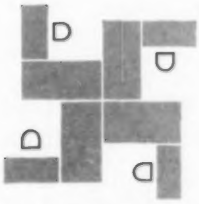
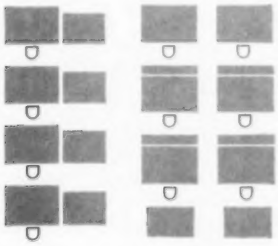


One of the many arrangements you can make with versatile "L" Contour tables.



Conventional Arrangement

Auto-Shift Arrangement

You couldn't choose a more immediate way of boosting your drafting room efficiency and production than with modern drafting tables. Now choose from two of the finest, most advanced tables on the market—from Bruning.

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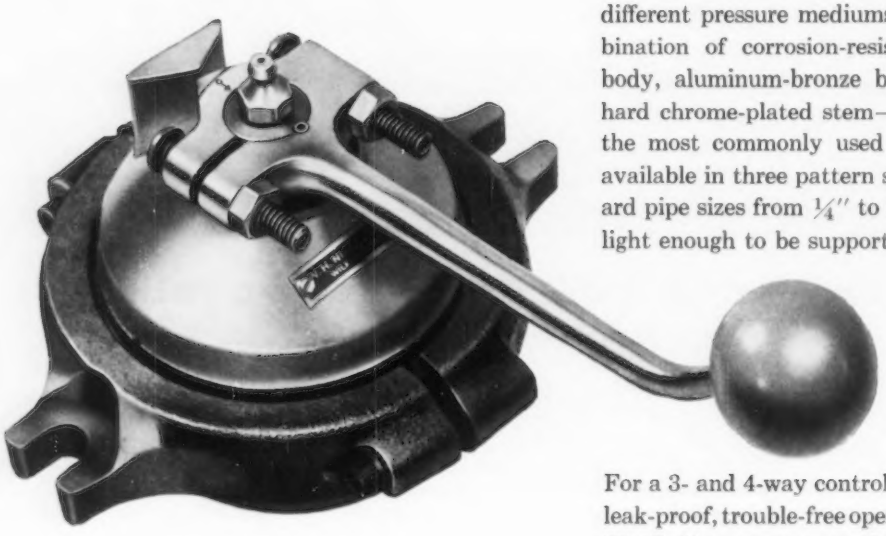

Highly-lapped metal-to-metal surfaces of this Nicholson control valve assure you leak-proof service. The O-ring stem packing and O-ring seal between the body and base make joints leak-proof without excessive bolt tension.

You can use the Model 300 with air, water, hydraulic fluid or oil as the pressure medium . . . at operating pressures to 300 psi. Use it to activate single- or double-acting cylinders. Simple and rugged, this valve provides accurate, repeatable control of equipment such as presses, hoists, clutches and chucks. Valve maintenance is no problem . . . all stem, base and disc bearing surfaces are lubricated through one easily accessible fitting on top of valve stem. Lubricant reservoir in base reduces frequency of lubrication.

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Write for Bulletin 300 . . . covering design, construction, sizes and applications for the Model 300

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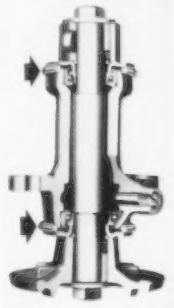
DOW CORNING CORPORATION

Silicone News

FOR DESIGN ENGINEERS No. 47

Icing No Problem to Moving Joints Protected with Silastic "O" Rings

Neither sleet, snow, heavy icing conditions nor rain can hamper the reliable performance of outdoor transmission line switches manufactured by Line Material Industries. Reason: Moving joints are protected with Silastic*, the Dow Corning silicone rubber; bearings are lubricated with an all-weather Dow Corning silicone compound.



Location of Silastic "O" rings is shown in the photo. Slightly larger in diameter than the joint openings which they seal, the "O" rings project outward, thereby suspending in cantilever any ice that may form. Any movement of a joint "pops" the ice off!

The "O" rings are made of Silastic because it remains soft and flexible from —130 to 500 F, far beyond the limits of organic rubber seals. This temperature range is more than a match for the extremes to which the switches are exposed. (Cont. Pg. 2)

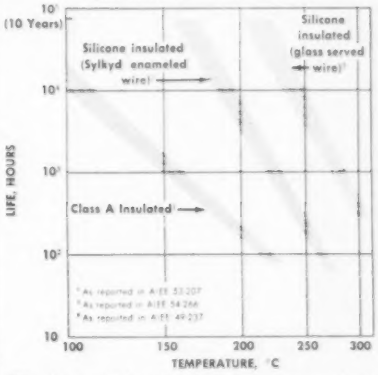
*T.M. REG. U.S. PAT. OFF.

50 TIMES MORE RELIABLE WITH SILICONE INSULATION

Increasing the reliability of magnetic brakes and couplings by insulating them with silicone dielectrics has paid handsome dividends to the Baylor Company, Houston. Result: greater customer satisfaction plus improved maintenance-free performance for their product.

Unconditionally guaranteed for a full year, Baylor Elmagco brakes and couplings are used in oil drilling to dissipate the tremendous energy developed while lowering drill strings. Three years ago Baylor started insulating this equipment with Dow Corning silicone insulation, without increasing their selling prices.

Life Expectancy of Class A and Silicone Insulated Motors



The heat-stable silicone insulation so drastically reduced Baylor's replacement costs during the one year warranty period that savings far exceeded the higher initial cost of using silicone insulation. Coil replacements dropped from 30% (Cont. Pg. 2)

MOTORS MADE MORE RELIABLE WITH SILICONE LUBRICANTS

A good example of the way Dow Corning silicone lubricants help designers assure maximum reliability and efficiency for tiny sensitive mechanisms is found in the new Synchron RPH timing motors developed by Hansen Manufacturing Co., Princeton, Indiana.

Like all Synchron timing motors, these units are only slightly larger than golf balls. Despite their small size, however, they frequently control complex processing operations where a slow-down or work stoppage would prove extremely costly.

Hansen engineers have found that one way to guard against failures in these midget mechanisms is to pack all brass and phenolic gears and steel pinions in the train, as well as the motor bearings, with a Dow Corning silicone lubricant.

Unaffected by aging or extreme temperature variations, the silicone lubricant enables these units to perform with maximum dependability and minimum maintenance. The silicone lubricant pays for itself, according to Hansen, by "eliminating leakers, withstanding high and low operating temperatures, and providing better storage life."

The new RPH timing motors operate at 600 rpm. Gear reductions of 1 to 45,000 are possible, giving output speeds as low as 0.8 rph. The housings are varnish-sealed — may be mounted in any position.

No. 476

FOR DATA RELATING TO THESE ARTICLES, CIRCLE REFERENCE NUMBER IN COUPON ON NEXT PAGE

MORE

DOW CORNING CORPORATION

Silicone News

NEW LITERATURE AND TECHNICAL DATA ON SILICONES

Silicones as Dielectrics. Just published. A 12 page, fact-filled must for design engineers. It's a convenient selection guide to the silicone dielectric most adaptable to particular applications that range from electronic components and assemblies to power distribution equipment and motors. *No. 480*

1958 Guide to Dow Corning Silicones—consists of 16 pages filled with data and illustrations suggesting ways in which you can cut costs, simplify designs, improve performance and add new sales appeal to your products with Dow Corning Silicones. Cross indexed for handy reference, this all-new Guide includes properties and uses for the silicone products developed in recent months. *No. 481*

Silicones in the B-58 is the subject of a recent article from AVIATION WEEK. It points up the wide-spread use of these new engineering materials to help military equipment meet more demanding performance requirements. Designers of industrial equipment also put the unusual properties of silicones to advantage. *No. 482*

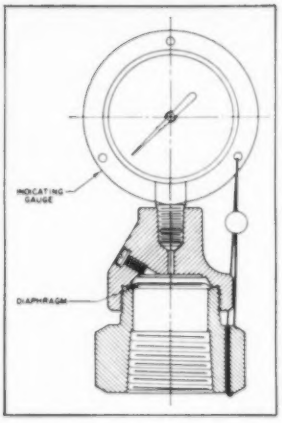
Antifoam B, the lowest priced silicone foam-killer, has greater stability than any other water dilutable silicone defoamer commercially available. Antifoam B will not separate, oil out, settle or precipitate in most applications; retains uniformity and effectiveness even under adverse storage or operating conditions. Ready to use, it requires no diluting or pre-mixing. *No. 483*

New Silicone Coating for paper and paperboard aids packagers and processors of sticky materials—it keeps gummy and tacky materials from sticking to all types of bags, boxes, innerliners, wrappings and interleaving sheets—it will not migrate nor contaminate goods in contact with it. Send for informative brochure containing sample papers. *No. 484*

Pressure-sensitive silicone tapes — that stick to wet or dry surfaces; form good bonds; have high dielectric strength; repel moisture; are not affected by corrosive chemicals—are described in a new folder designed to help you choose the tape best suited to your application. *No. 485*

SILICONE FLUID WIDENS PERFORMANCE RANGE

By hurdling the performance barriers imposed by organic fluids, Dow Corning Silicones improve the designs of many products where fluids are used as damping, coupling or springing media. This application from the United States Gauge, Sellersville, Pa. provides a good demontsration of the versatility and economy of silicone fluids.



These gauges are designed to measure the pressure of fluids too corrosive for ordinary pressure gauges. USG makes them corrosion-free by separating a metallic diaphragm from a Bourdon spring with chemically-inert Dow Corning 200 Fluid. The cost per unit for the silicone fluid—only 30 cents.

Compressing only 10.9% at 20,000 psi, the Dow Corning 200 Fluid transmits pressure instantly to assure quick, accurate readings. It does not corrode actuating elements. What's more, it makes the gauges operable over a far broader temperature span than possible with even the best organic fluids.

Engineers at United States Gauge cite these reasons for standardizing on Dow Corning silicone fluids for over seven years: "Silicone fluid is specified primarily because it is noncorrosive to the materials used, including the cold rolled steel sockets. Should the diaphragm be ruptured, the fluid will not cause dangerous chemical reactions to introduce toxic or taste materials to edible products. It has the low vapor pressure necessary to permit the evacuation incident to solid filling, and it will not absorb water to interfere with the evacuation process." *No. 477*

SILICONE INSULATION *(Cont.)*

of total output to a mere 0.55%, only one-fiftieth of the previous rate.

While the brakes are designed to dissipate energy up to 5000 hp, actual rates are frequently much higher. The silicone insulated brakes operate efficiently despite temporary overloads that would quickly burn out any other type of insulation.

Recently, for example, the cooling water supply failed while a brake was lowering 12,600 feet of pipe. Baylor engineers calculate this pipe actually developed 1,587,000,000 foot pounds of energy. The overheated brake reportedly glowed almost red hot. While the heat warped and ruined the rotor, the silicone insulated coils were undamaged and later tested out as good as new! *No. 478*

SILASTIC "O" RINGS *(Cont.)*

"All-weather" considerations also prompted L-M to specify Dow Corning 11 Compound as the lubricant for the joints and bearings of these switches. In their words, "These switches are often located in industrial areas where dilute acids and alkalis are found in the atmosphere. However, this presents no problem for Dow Corning 11 Compound since it is unaffected by these agents. In addition, Dow Corning 11 is nongumming, nonmelting, noncorrosive, and water repellent assuring the switches years of trouble-free operation. *No. 479*

Dow Corning Corporation, Dept. 862, Midland, Michigan

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PERSPECTIVES

in design and development . . .

After 20 Years What Then?

What will be the most important economic problem facing the United States in the next 20 years?

The Committee for Economic Development asked this question in an open contest to mark its 15th anniversary. The private research and educational group (CED is supported by business firms), offered 50 prizes of $500 each for the best answers. CED also invited papers from 50 notables here and abroad; their replies were just released. The results were a surprise.

Not 50 Different Answers

Instead of giving up to 50 different and contradictory answers, two-thirds of the group agreed on one of three problems: (1) How to up-date American policy on tariffs and foreign aid; (2) How to combat creeping inflation without causing unemployment; and (3), How to avoid wholesale congestion in our booming metropolitan areas. Furthermore, this group treated the three problems in roughly the same way. Here's a summary of their thoughts.

Trade and Aid

Most of the interesting comments on international trade and aid came from foreign economists and statesmen, including Lester B. Pearson of Canada (see p 37, Dec. 30 '57), and Jean Monnet of France.

Monnet, proponent of European integration, criticized the capitalist free world for resting on its past achievements and said that US foreign economic policy would have to adapt itself to three new forces: Soviet growth, economic unification of Europe, and a boom in the underdeveloped countries. Paul Prebisch, Chilean UN official, thought we could learn something from the Communists, who don't give as much aid to underdeveloped nations, but who win more friends because they give it with no political strings attached.

Professor W. A. Lewis of Manchester, England, thought US capital could not do the job, because poor countries need considerable funds for such things as roads, schools, dams, etc., before they can attract private investment.

Pearson says that the US is reluctant to rely on "genuine" international trade, and called our preference for branch plants abroad a sort of trading with oneself, not others.

Not all criticism came from abroad. Frank Knight of the U. of Chicago said, "The chief economic sin of business is the absurd demand for tariff protection."

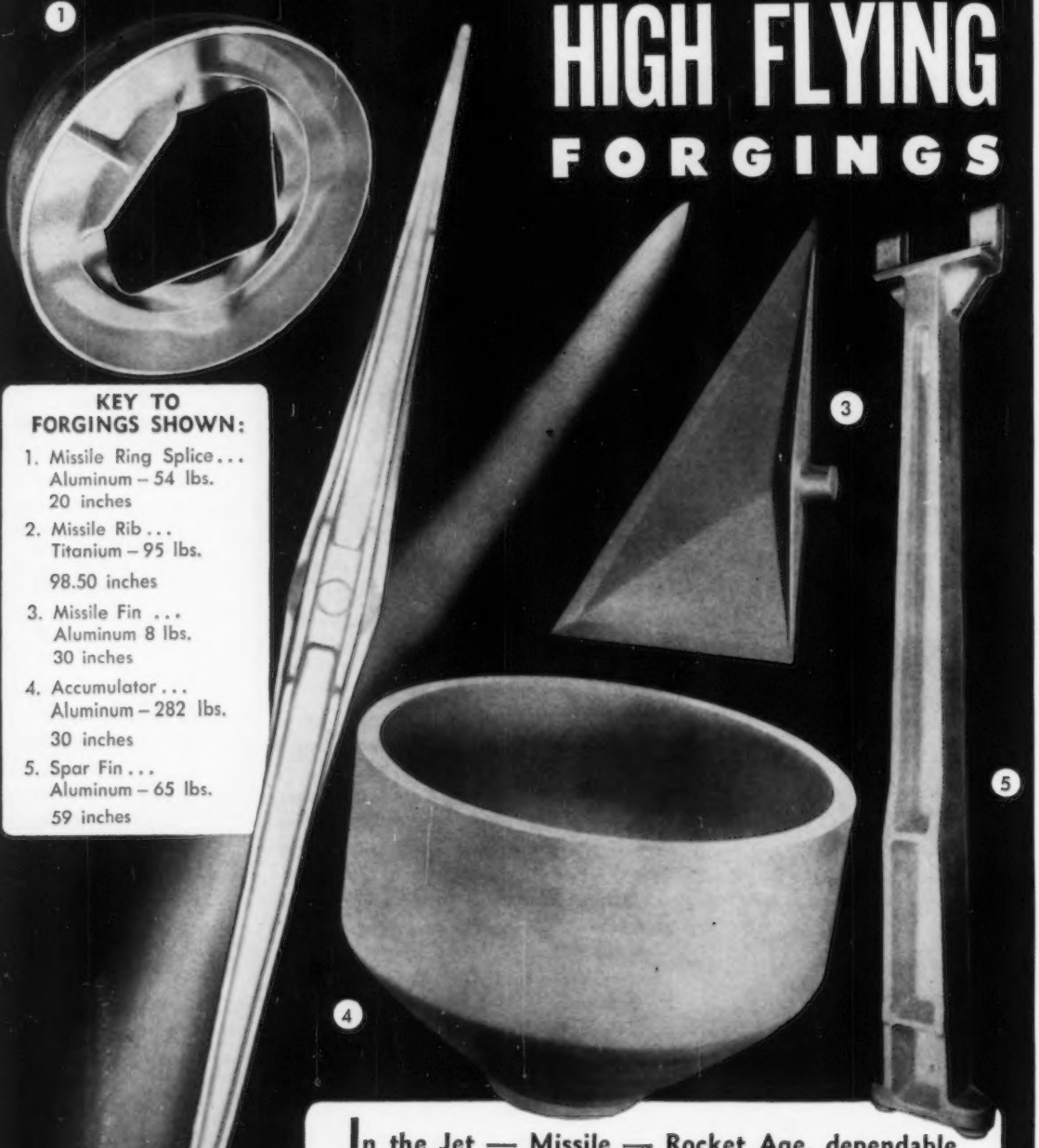
The general theme was that we as a nation don't have a good foreign aid program, we don't realize how important foreign trade is, and we are trying to cash in on international trade while letting 19th-century special interests determine the policies.

Inflation

There were few novel contributions on this topic—just a rehash of the well-known difficulties of stopping the creeping "cost-push" variety of inflation. There was much moralizing about the inequity of inflation with some speculation about how dangerous it could get. But few suggestions on what to do about it. And no one expects a runaway inflation. In fact,

(Continued on page 47)

HIGH FLYING FORGINGS



KEY TO FORGINGS SHOWN:

1. Missile Ring Splice... Aluminum – 54 lbs. 20 inches
2. Missile Rib... Titanium – 95 lbs. 98.50 inches
3. Missile Fin ... Aluminum 8 lbs. 30 inches
4. Accumulator... Aluminum – 282 lbs. 30 inches
5. Spar Fin... Aluminum – 65 lbs. 59 inches

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the most convincing observations came from the economists who picked other problems to write about, and who told briefly why they had not selected inflation. As Alvin Hansen of Harvard said, "The simple fact is that the US does not have any serious structural bottlenecks, the bane of all inflation-sensitive economies."

The general theme was that inflation will be a continual headache over the next 20 years, but like the common cold it will be easier to learn to live with than to cure.

Metropolitan Population

There were a number of worries here. Professor Hansen said, "the tidal wave of population will present economic, fiscal and social problems the magnitude of which we have scarcely yet caught a glimmer. The big problem will be finance and the fact is that an obsolete, Balkanized network of multiple governments will not be able to cope with the coming surge of 55 million more urbanites."

Barbara Ward of the London *Economist* put the same matter in terms of what the American public would want to pay in the next 20 years, charging that democracy, in the US or elsewhere, has not yet decided to spend the necessary amount for schools, hospitals and other municipal projects.

The general consensus here: Face up to the major problem of urban redevelopment, or take the consequences of urban bankruptcy, social disorder and economic chaos.

Enforced Consumption

David Riesman, sociologist, noting our prosperity, is quite pessimistic about the psychology of enforced consumption. He said, "We are a generation prepared for Paradise Lost, who do not know what to do with Paradise Found." Riesman feels that there is no ferocious desire for material things, particularly the standard package of consumer gadgets, let alone money for its own sake. He said that we must ask the fundamental question: "Abundance for what?" and come up with a better answer.

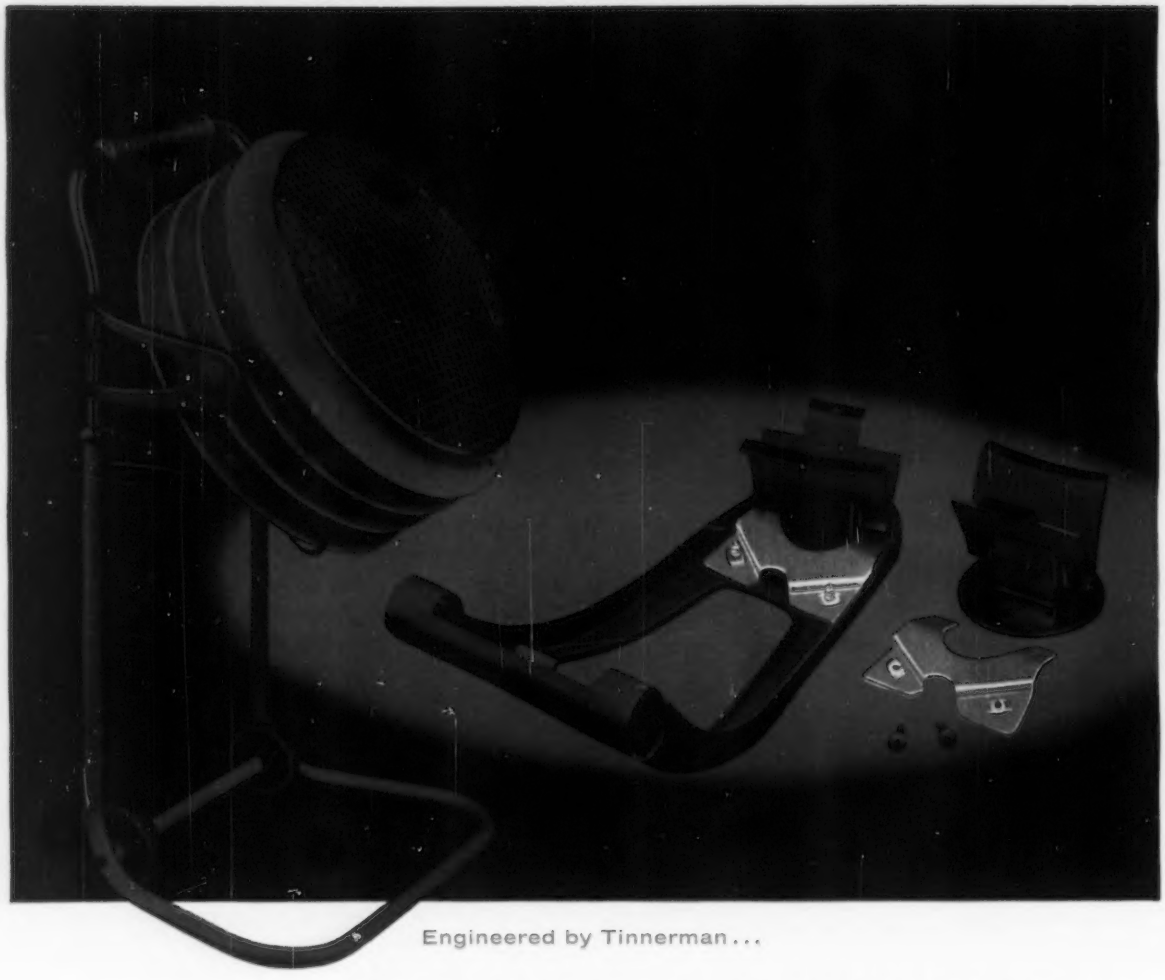
Moses Abramovitz didn't question the great potential for growth, but concluded that, "We cannot escape the fact that the sheer expansion of productive capacity has lost much of its former significance. We may discover that the economic progress of the next generation was an empty achievement, not only in the eyes of people in other countries, but perhaps still more in our own."

One Picked National Defense

Kenneth Boulding of Michigan decided that the problem of national defense was of most importance, and came up with a really pessimistic viewpoint for the next generation. His main worry is that with Russia and the US in the middle of a never-ending weapons race, our system of national defense has really broken down. His main point is that: "the armed forces of the world have become the deadly enemies of the human race. The military does not intend this, of course, they are no more malevolent than the rest of us. But just as businesses defending themselves in a depression creates a system that drags down everybody, so we are now in a situation where the efforts of each nation to defend itself form a system that leads to the destruction of all. Just as we need government to dampen the business cycle by appropriate cybernetic action, so we must have a minimum world government to dampen the war cycles. Only thus can we lift from our heads the shadow of total destruction."

Boulding's solution is total, universal, policed disarmament. How we get it he didn't say. "But we have to, or there won't be any other economic problems to worry about."

—Paul Anderson



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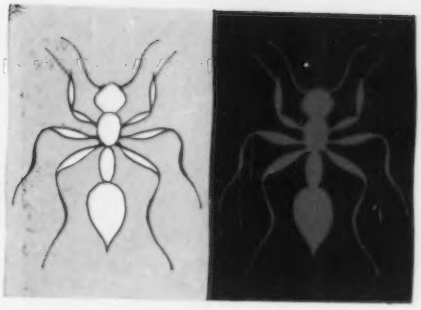
Product Engineering

February 3, 1958



The PARABLE of the ANTS

Once upon a time, there were two colonies of ants. One was on the sunny side of a wall, the other on the shady side. The white ants on the sunny side built a tremendous anthill, with special tunnels, patios, and all modern conveniences. They also used the sun to brown their skins, to light and heat their hill. After a time, they began to think it was *their* sun and that nobody else had any right to it.

The red ants on the shady side built their anthill larger too. But it was always damp and miserable. So they began to hunt drier places, and they put little colonies in chinks in the wall.

This alarmed the white ants, so they began to work up their side of the wall. There they found crickets, grasshoppers and moths, with which they allied themselves, talking of a better world and giving of their own stores to keep the other insects friendly.

Then there came a plague of beetles, German and Japanese, and the two anthills combined in a long fight to drive them off. The two anthills were very friendly for all that time, and the whites gave food and supplies to the reds. And the beetles were finally subdued.

Of course, the allies at once fell out, each hill claiming it had done the giant's share. And each learned some of the tricks of the beetles and began to improve on them. And the reds began to want a place in the sun too.

The whites, with the sun on their side, were complacent. They built more patios, more tunnels, provided soft linings for their nests, made pictures and music. But the red ants began a single-minded drive to reach the top of the wall—and the sun. They taught every red ant a specific job; only a few were allowed to dabble in music, pictures, and patios. And their colonies moved up the dark side of the wall, the builders winning more food and a better place.

Now the white ants began to worry. They talked of the "red menace"—they were great talkers. And they began five separate drives for the top of the wall, saying the best would succeed first, and that all would be atop the wall before the reds. They also fed more to the moths, grasshoppers and crickets, certain that this would help.

They were wrong. The red ants got there first—and were now in a position to harass the white ants with rolled-down pebbles that ruined patios and clouds of wall dust that at times obscured the sun.

The white ants were in a panic. Now they too began to train more ants to build. And they favored the builders. But the philosophers and artists among them saw their places being lost. So they set up a clamor, saying that they too should have more. And the great resources of the white ants were not aimed in a single direction, but were partly spent on bigger tunnels, bigger patios, and more music. Some whites even spent more time sunning themselves, to become browner. And most of the moths, grasshoppers and crickets began to act very neutral, still taking the white-ant help but offering less and less in return. This was indeed a dilemma.

MORAL: When it's a matter of survival, even ants forget a rich uncle.

Templet guides scribing for removal of masking as part is prepared for . . .

Chemical Milling

Artists have etched metals for centuries. Now, spurred by the needs of aircraft designers, the technique has been speeded up to give large-scale production of parts that other shaping methods cannot handle easily. Here is first design data

C. H. LUNDQUIST, *President*
U. S. Chemical Milling Corp.

The process called chemical milling is still so much in its infancy that its potential is greater than its achievements. Aircraft builders are familiar with this big-scale and modernized version of etching–it gives them the weight reduction needed for structural parts. But planners in this field, and most other designers, are still unaware of the method's other industrial possibilities.

These are based on several over-all advantages. For example, shaping is done by single or multistep immersion in an etch bath, without need for complex tools. Also, large areas are milled on one or both sides at once–instead of separate steps on different machines. The etching agent mills away the metal at a precisely controlled rate–an average of 1 mil per min. This may seem like waste of material; but cost of material these days is not as important as fabrication costs. Specifically, the process will:

- Inexpensively remove material too tough to machine, or too thin or intricate to hold.
- Handle many parts simultaneously with semiskilled labor, once tooling has been established.
- Accurately contour pre-formed complex shapes, and mill large areas rapidly.
- Cut hard alloys with low distortion and without work-hardening–eliminating need for annealing, and without introduction of residual stresses.
- Taper material to minimum thickness of 0.002 in.
- Provide cleaned and acid-treated surfaces ready for painting if desired.

Principal disadvantages are: Internal corners cannot be square–they are rounded to depth of the cut; masking is required to prevent etching where not wanted.

Many metals including ordinary steel can be chemically milled. With aluminum and magnesium, main advantage is speed of metal removal over large surfaces. Stainless steels, titanium, nickel- and cobalt-base alloys, which are tough and will work-harden with machine tool cutting, offer even greater savings because the technique eliminates need for expensive dies and other tooling.

DETAILS OF TECHNIQUE

The basic steps are: cleaning the parts, deoxidizing, drying, masking, and etching for a specified time. The part is then quenched to deactivate any etchant that remains, and the mask and smut are removed.

Close tolerances can be held, but larger tolerances obviously allow lower costs. Depth tolerances must be considered in addition to the original material toler-

ances. For cuts of 0.125 in. or less, standard tolerance is ±0.003 in. (0.005 in. on deeper cuts). Very light cuts can be held to ±0.002 in. or less. Dimensional tolerance of $\frac{1}{32}$ in. is generally recommended. If sections are thin and intricately curved, a tolerance of $\frac{1}{16}$ in. may be required. In this case, a local deviation of $\frac{1}{32}$ in. can generally be held.

Grain orientation from working the original metal will affect both the final surface finish and strength. Usually the sheet material is formed so direction of max strength will be in the direction of the load. This is more important with chemical milling because grain orientation also affects etch rate and undercut. For lateral etching, the rate must be determined empirically and compensated for in masking. Unmilled areas needed for stiffening should run parallel to the grain for max strength. For adequate circulation of the etchant, the distance between these lands should be at least 0.125 in. greater than twice depth of cut. For effective masking, width of lands should not be less than 0.10 in.

Surface finish is a function of the alloy, etch rate, and depth of cut. Influence of alloy is dominant. Certain alloys, particularly titanium, magnesium-thorium, Inconel, Monel, and Incoloy can be finished to 50 microin. RMS because the etching solutions tend to level out marks and blemishes. Increasing the etch rate improves the surface but aggravates end-grain pitting, which lowers fatigue life and makes tolerances difficult to hold. Depth of cut also affects surface finish—for example, cuts up to 0.150 in. can give a finish of 100 to 125 microin. RMS, while for cuts up to ½ in., a finish of 200 to 250 microin. RMS is more realistic.

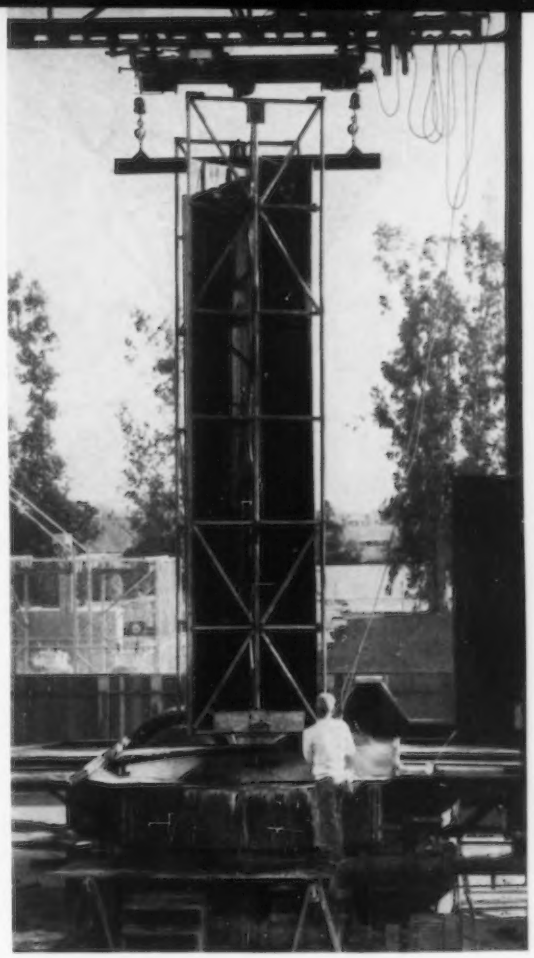
Fillet radii are approximately equal to depth of the cut. If larger radius is needed, milling is started on an oversized part to increase depth of cut.

Deep cuts on both sides of a part should be avoided because gas from etching may be trapped and slow the reaction locally. Best way to etch a deep cut is to face it up in the bath. Specifying deep cuts on both sides increases costs because placing the cuts vertically will trap gas at the upper edge, and milling each side separately will double etch time.

Uniform tapers are made by a single raising and lowering of the part being etched. Long parts and shapes with irregular cross-sections can be tapered easily, but for lower cost, tapers should be limited to one direction on each part. Each direction requires a separate masking operation.

Bosses and holes can give trouble. They swirl the solution and increase the etch rate locally. Holes should be drilled after milling and bosses, if required, kept to minimum size.

Heat-treating before milling usually does not affect surface finish. Aluminum is an exception—the treatment refines its grains and gives a smoother finish. Before milling, scale and other masking deterrents have to be removed. Carbon steels are usually heat-treated after milling to remove any hydrogen embrittlement. For parts which become thin after milling, a compromise must be reached between hydrogen embrittlement and the tendency of these thin sections to warp during heat treatment.



Dipping a large part . . .
looks like this. A taper is formed by lowering, then raising, the part at a controlled rate.

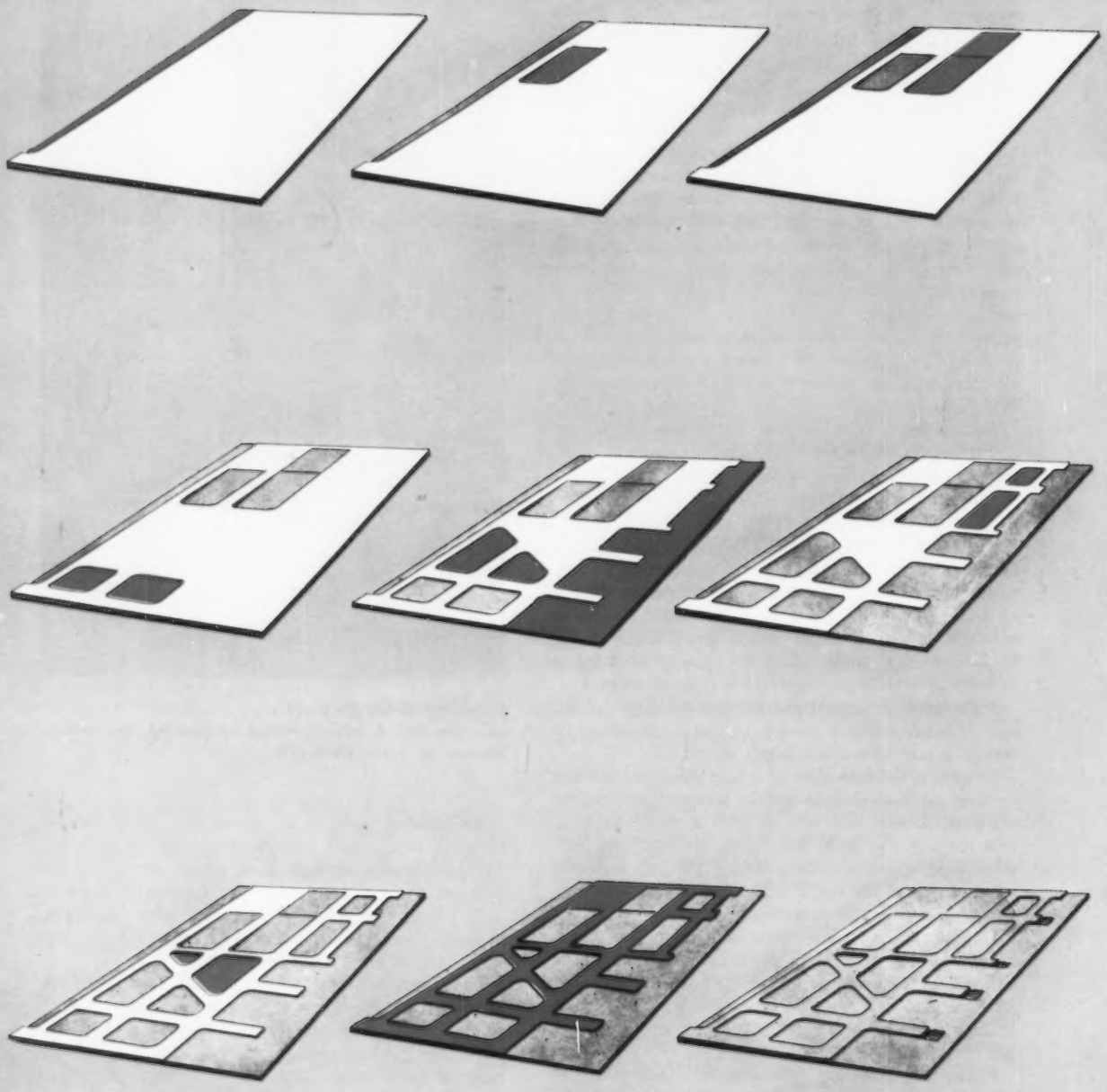
Pre-forming parts is an advantage. They can be stamped, bent, rolled, stretchformed, spun or extruded. Milling complex surfaces is as simple as milling flat ones, without need for expensive contouring machine tools. Ridges or mismatch lines left after machining or casting will remain, but radii of ridges will decrease while radii of grooves are increased.

Lubricants left from machining and especially from spinning must be thoroughly removed so masking will adhere better. Silicone lubricants must be avoided because they resist all normal cleaning. Spun parts usually have lubricant worked into the metal deep enough to need flash milling for removal.

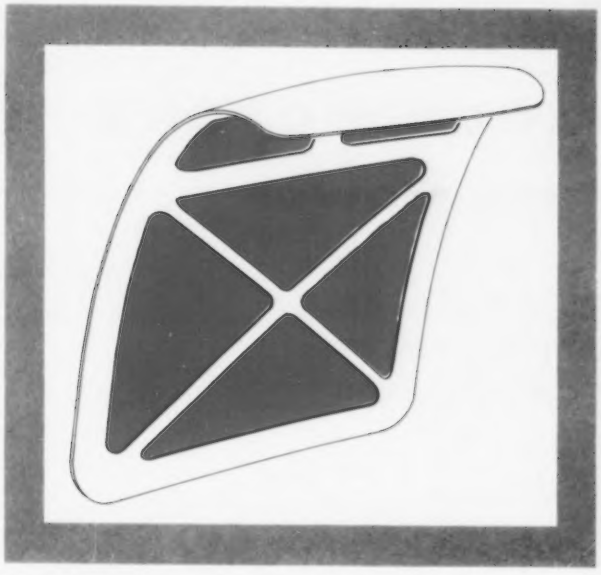
ECONOMICAL MASKING

Before a part can be etched, areas to be left unmilled must be protected by an inert material, usually neoprene or vinyl. With present technique, this accounts for much of the over-all labor, so cost of masking largely determines total cost. Fortunately, this step can be limited. Careful selection and design of areas will avoid needless masking.

Most common method is to dip the part into a masking solution, oven-bake it, scribe-outline the areas to be etched, and strip off the maskant. The cost here in-



Nine steps . . .
in etching sequence combine cumulative effect to give this complex structural panel for jet plane. Color shows section milled down in each step.



Chem-milled trunk lid . . .
is lightweight integral unit, needs less fabrication than conventional lid with stiffeners spotwelded to outer skin.

Plastic templet . . .
must be carefully cut to show scribing areas where masking is to be removed preparatory to etching.

creases with number of areas to be etched and lineal inches of scribing.

When milling in large quantities, manual labor can be reduced by other masking methods such as photographic application and using precut, pressure-sensitive tape. However, tape is expensive. Spraying the masking through a templet eliminates hand stripping, and can be adapted to high-speed, low-cost production. Sharp definition is hard to obtain, particularly on deep cuts, but this is usually not a serious problem in commercial work like automobile body panels.

Simplified patterns lower costs, too, because intricate designs require more care in scribing and stripping. Each complex templet for scribing costs $200 to $300. Tooling costs can be reduced by designing multiple patterns into one templet and differentiating them by a color code.

Templets are usually made of epoxy-fiberglass laminate because it is relatively easy to cut and changes can be made quickly. For multiple steps, the templet must be made with supporting bridges between the larger scribing guides and the smaller ones. After scribing along the guide, a straight edge is laid between the bridged areas and the scribed lines are connected. Deepest cuts are milled first, followed by each shallower one in turn. If a minimum of ½ in. lateral space is kept between successive steps, they can be scribed using only one templet.

POSSIBILITIES FOR THE METHOD

What the future holds for chemical milling are seen in the following applications:

An example of the complex parts it can give is in the manufacture of cast impellors for centrifugal compressors. For proper solidification, the casting must be made thicker than needed. Chemical milling will quickly remove excess material, thereby reducing centrifugal loads, and increasing the safety factor.

Chem milling also allows freedom of choice—between forged, extruded or cast parts—that gives best mechanical properties. For the material to flow properly during forming, the parts may have to be oversize. The etching will cheaply remove excess material.

Hard, difficult-to-machine, magnetic materials can be etched without destroying their magnetic properties.

Gas turbine blades can be milled from superalloys, simply by twisting flat bar and tapering it in etchant to form a blade.

Sheet-metal panels—for example, auto trunk lids—can be stiffened by using slightly heavier stock and milling it to leave stiffeners. Such sheet can be bent and then etched to leave reinforcing angles at the corners. These applications for structural panels are lighter, stiffer, require less fabrication, and are already prepared for plating, painting or other surface finishing.

The etching also makes inspection easier. This may happen several ways. Small cracks are made more noticeable. Segregation and high residual stresses show up by causing a change in rate of etching.

EDITOR'S NOTE: Design information on other recently developed metalworking processes:

"These Gaskets Are Sprayed On," Oct 14 '57, p 90. Metal spray technique coats coverplate with aluminum.

"Castings as Strong as Forgings," June '57, p 170. Mold construction uses anodized aluminum combined with controlled pouring rate; adaptable to casting aluminum, magnesium, iron and steel.

"Acid Etching and Electroforming Precision Parts," July '56, p 194. Describes application of these two techniques, and how to use photographic masking.

NEMA standards for . . .

Those SIZE-REDUCED MOTORS with the Same Power

As motor design improves, ratings need revision too. NEMA has now extended its rerating program to motors from 40 to 125 hp. Changes are reviewed here through the eyes of a motor designer.

R. Y. NEWTON

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Economy and performance are the two things considered first when specifying a motor. The engineer has no particular desire to become an all-around motor expert, and usually prefers to find specifications quickly in manufacturers' catalogs, handbooks, or a standards-listing publications such as NEMA's *Motors and Generators*, MG 1-1955.

Enlarging its helpfulness, NEMA has in the past year extended its program of rerating motors to 125 hp at 1800 rpm and 150 hp at 3600 rpm. Motor manufacturers are already taking advantage of these standards which, in general, specify smaller frame sizes for the same power ratings. Cooperation has been excellent, considering the fact that compliance is optional and motor manufacturers may build what they choose.

Motor ratings below 40 hp have been fully discussed in previous articles (see Editor's Note). Covered here are the new reratings in the range of 40 to 125 hp at 1800 rpm, down to 20 hp at 900 rpm, and up to 150 hp at 3600 rpm.

WHY REVISE STANDARDS?

Have specifications been downgraded, so that the customer gets less motor for the same nameplate rating? Can the rerated motors take less abuse? Must they be applied differently? The answers are no; the motors do everything as well or better than the older-rated ones but are lighter, smaller, more reliable, more attractive, better standardized.

Without periodic rerating, motor manufacturers would be limited to obsolete standards or to a nonstandard product. Either includes a penalty. With rerating, all motor builders can take better advantage of latest technological progress in:

- Materials—such as polyester insulation sheets and magnetic steel sheet.
- Manufacturing methods—including application of new and higher quality films to magnet wire, and new developments in welding silicon steel.
- Design methods—greater knowledge of motor operating phenomena.

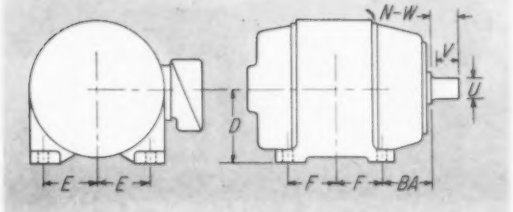
Tests and performance characteristics (Part 4 of MG 1-1955) remain unchanged for each given rating,

FRAME ASSIGNMENTS FOR SQUIRREL-CAGE MOTORS
Designs B and C, 40 C continuous

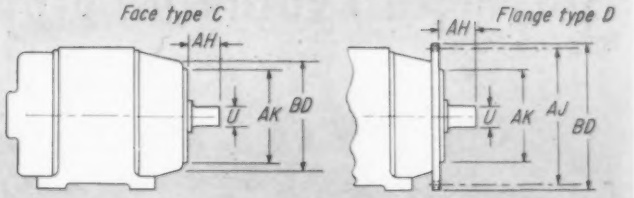
Hp \ rpm	3600		1800		1200		900	
	old	new	old	new	old	new	old	new
DRIPPROOF								
20							404	364U
25					404	364U	405	365U
30					405	365U	444	404U
40			404	364U	444	404U	445	405U
50	404S	364US	405	365US	445	405U	504	444U
60	405S	365US	444	404US	504	444U	505	445U
75	444S	404US	445	405US	505	445U		
100	445S	405US	504	444US				
125	504S	444US	505	445US				
150	505S	445US						
TOTALLY ENCLOSED, FAN-COOLED								
20							404	364U
25					404	364U	506	365U
30					405	365U	444	404U
40	405S	364US	405	364U	444	404U	445	405U
50	445S	365US	444	365US	445	405U	504	444U
60	445S	405US	445	405US	504	444U	505	445U
75	504S	444US	504	444US	505	445U		
100	505S	445US	505	445US				

DIMENSIONAL COMPARISON, OLD AND NEW MOTORS

OVER – ALL



SHAFT – END



Hp at 1800 rpm	NEMA Frame		Dimensions, in.							
	old	new	U	V	N-W	Keyway	E	F	BA	D
40	404		2⅛	6⅛	6⅜	½ x ¼	8	6⅛	6⅝	10
40		364U	"	"	"	"	7	6⅜	5⅞	9
50	405		"	"	"	"	8	6⅛	6⅝	10
50		365U	"	"	"	"	7	6⅛	5⅞	9
60	444		2⅜	6⅞	7⅛	⅝ x 5/16	9	7¼	7½	11
60		404U	"	"	"	"	8	6⅛	6⅝	10
75	445		"	"	"	"	9	8¼	7½	11
75		405U		"	"	"	8	6⅞	6⅝	10
100	504U		2⅞	8⅜	8⅝	¾ x ⅜	10	8	8½	12½
100		444U	"	"	"	"	9	7¼	7½	11
125	505		"	"	"	"	10	9	8½	12½
125		445U	"	"	"	"	9	8¼	7½	11

Hp at 1800 rpm	NEMA frame		Dimensions, in.					
	old	new	AK	AJ	BD max	AH	U	Keyway
FACE TYPE								
40	404C	364UC	12½	11	15¼/15½*	6⅛	2⅛	½ x ½
50	405C	365UC	12½	11	15¼/15½*	6⅛	2⅛	½ x ½
60	444C	404UC	16	14	18	6⅞	2⅜	⅜ x ⅜
75	445C	405UC	16	14	18	6⅞	2⅜	⅜ x ⅜
FLANGE TYPE								
40	404D	364UD	14	16	18	6⅜	2⅛	½ x ½
50	405D	365UD	14	16	18	6⅜	2⅛	½ x ½
60	444D	404UD	18	20	22	7⅛	2⅜	⅜ x ⅜
75	445D	405UD	18	20	22	7⅛	2⅜	⅜ x ⅜
100	504D	444UD	18	20/22*	22/25*	8⅝	2⅞	¾ x ¾
125	505D	445UD	18	20/22*	22/25*	8⅝	2⅞	¾ x ¾

*new/old

even though the motor is physically smaller. The standards that remain the same cover:

- Temperature rise
- Definitions of enclosures (Part 1 of MG 1-1955)
- Locked-rotor torque
- Locked-rotor current
- Breakdown torque
- Pull-up torque

DIMENSIONAL CHANGES

The charts show relationships between ratings, frame sizes, and critical dimensions for motors in the 40 to 125-hp range. Note that usually the frame size for a given hp is down 2 frames, or 1 dia; and for a given frame size, hp is up 2 steps. For example, a new drip-proof 100-hp, 1800-rpm motor fits an old 60-hp, NEMA-444 frame. The suffix *U* is used throughout to designate the rerated motors.

Important mounting dimensions—shaft height (NEMA dimension *D*), distance along the mounting holes (*F*) and across the mounting holes (*E*)—stay the same for a given frame size in the 40 to 125-hp range. This is not always true for motors below 40 hp. To install any rerated motor in place of an old one, a transition base may be obtained; it uses the same foundation bolts and adjusts the motor axially and vertically to locate the shaft extension properly.

Shaft-extension dimensions, however, stay with the rating. A rerated motor of a given hp has the same dia, length and keyway size as a previously rated motor of the same hp—so the same coupling, sheave or gear may be used.

New dimensions were established for flange-mounted (NEMA type D) and face-mounted (NEMA type C) motors. The type C dimensions are tentative only, but probably will be final. For both, rabbet diameter *AK*, bolt circle *AJ*, dia of mounting surface *BD*, and shaft dimensions stay with the rating in most instances, rather than with the frame size. Conversion here should be no problem.

HOW BELTING IS AFFECTED

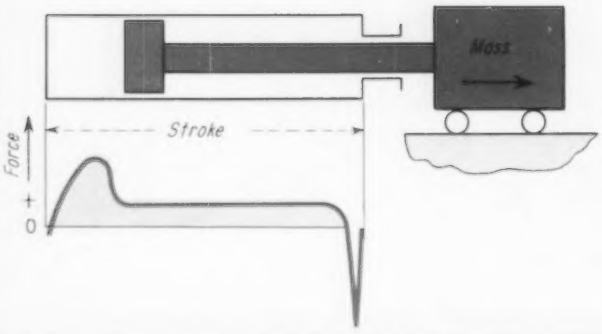
The range of ratings recommended as suitable for flat belting remains unchanged. Rerating for V-belting has been extended to include up to 125-hp, 1800-rpm motors (with 11-in. min sheave dia). Min sheave dia and max sheave widths were standardized to limit bearing loads.

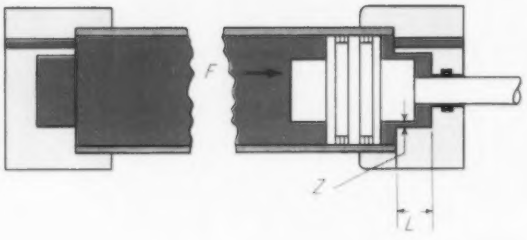
EDITOR'S NOTE: The NEMA motor rerating program started in 1952. A summary of progress is found in: "What the New NEMA Standards Mean," Dec '53, p 144; "NEMA Rerate Motors," Nov '55, p 195; and "NEMA Standards for DC Motors and Generators," Mid-Oct 56, p H10.

The complete Motor and Generator Standard MG-1-1955 (revised Sept '57) is available from NEMA, priced at approximately $9.50. For this publication, and other information concerning the NEMA standards, write to National Electrical Manufacturers Association, 155 E. 44th Street, New York 17.

solving a hydraulics problem . . .

WHEN PISTONS NEED





1 Undamped cylinder . . .
has high forces to accelerate mass, at start of stroke, then reduced force to hold constant velocity, and finally experiences shock forces at end during reversal of mass.

2 Annular clearance . . .
in cavity of cylinder cap serves as flow restriction for this dashpot. Oil then escapes at outlet port.

It's necessary to take the bang out of end-of-stroke forces that damage hydraulic cylinders and other components. The author describes braking and reversing methods that allow a variety of displacement-time responses.

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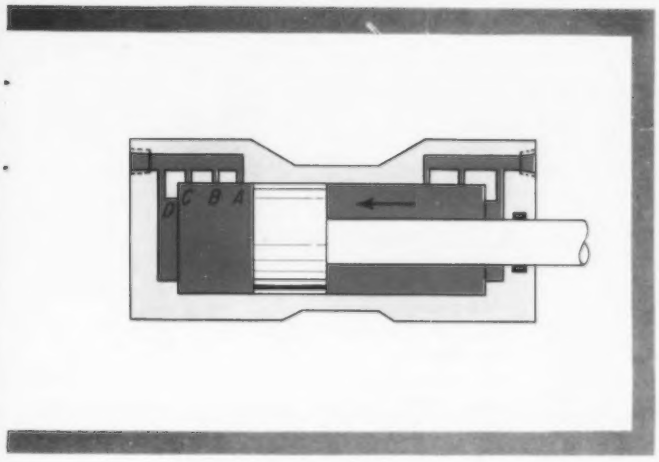
Cincinnati, Ohio

SYMBOLS

a	acceleration and deceleration, ft/sec²
M	mass, lb-sec²/ft
F	mean dashpot resistance, lb
H	hydraulic head, ft
P	mean dashpot pressure, psi
P_B	back pressure, psi
ΔP	differential pressure, psi
L	dashpot depth, ft
R	radius of dashpot, in.
Z	annular clearance, in.
V	velocity, ft/sec
Q_G	discharge, gpm
Q'	discharge, ft³/sec
Q''	discharge, in³/sec
B	capacity of dashpot, in.³
S	specific gravity
C_D	coefficient of discharge
T	time, sec
A'	area, ft²
A''	area, in.²
G	32 ft/sec²

BRAKES



3 Communicating orifices . . .
provide increasing resistance to oil flow as dashpot piston moves to left and covers holes. On return stroke, induced flow is restricted less and less.

Pistons, like people, are hard to stop once they get going. With hydraulic pistons, however, the control need not be difficult. Some of the same oil-flow principles that push the piston can also be put to work as a brake.

Result is less shock caused by end-of-stroke dynamic forces—the shock that creates problems of noise, wear and high stresses. When created by a suddenly applied load, these forces give a deflection which may be twice as much as when the same load is applied slowly. But that slowness can itself be a drawback. The answer is skillful compromise—decelerate with a controlled force strong enough to reverse the stroke swiftly, but not so fast that it shocks the operating components.

Hydraulic damping and shockless reversal can be had with flow-restriction or pressure-reducing devices. These include servo-controlled variable pumps, flow-control valves, cylinder modifiers (orifices, special pistons), and other power cutouts or reducers.

ANNULAR-CLEARANCE METHOD

A familiar component for this work is the hydraulic shock absorber (dashpot). It limits axial piston velocity where and when desired by trapping oil ahead of the piston, then releasing it through a restriction, slowly and with predetermined control.

Here is an example of how to calculate an annular-clearance restriction, Fig. 2. Assume that at the start of dash-pot action, inertia forces alone are dissipated through the ejection of dashpot oil. Hence, kinetic energy of moving parts equals work done during penetration of the dashpot

$$\frac{1}{2} M V^2 = FL$$

The acceleration (and deceleration) is

$$a = \frac{F}{M}$$

Assuming a parabolic velocity-time curve, then

$$V = aT/2$$

Mean dashpot pressure is

$$P = \frac{F}{\pi R^2}$$

Differential pressure is

$$\Delta P = P - P_B$$

Standard equation of flow issuing from an orifice is

$$Q' = C_D A' \sqrt{2GH}$$

Assume that annular clearance of dashpot is equivalent to an orifice, and then convert to conventional units

$$Q_G = 238\, RZC_D \sqrt{\frac{\Delta P}{S}}$$

An assumed value of the coefficient C_D may be checked against the Reynolds number of the calculated flow and adjusted if it deviates too much from what experience has shown to be reasonable. For Reynolds numbers below 100, C_D may vary from 0.1 to 0.7.

The time required to eject the dashpot oil is

$$T = 0.26 \frac{B}{Q_G}$$

Suppose that a piston velocity V of 1.1 ft/sec is selected, and that the following data are known: M = 64 lb-sec²/ft; L = 4 in.; R = 1 in.; B = 12.5 in.³; S = 0.85; C_D = 0.62, and ΔP = 30 psi. Then,

$$F = \frac{MV^2}{2L} = \frac{(64)\,(1.1)^2\,(12)}{(2)\,(4)} = 116 \text{ lb}$$

$$a = \frac{F}{M} = \frac{116}{64} = 1.81 \text{ ft/sec}^2$$

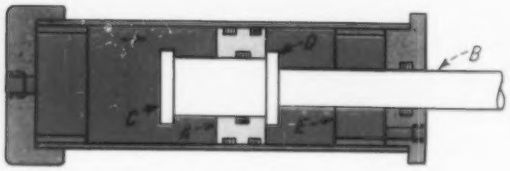
$$T = \frac{2V}{a} = \frac{(2)\,(1.1)}{(1.81)} = 1.22 \text{ sec}$$

$$Q_G = 0.26 \frac{B}{T} = 0.26 \frac{12.5}{1.22} = 2.66 \text{ gpm}$$

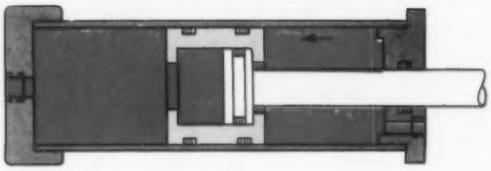
$$Z = \frac{Q_G \sqrt{S}}{238 RC_D \sqrt{\Delta P}} = \frac{(2.66)\,(0.92)}{(238)\,(1)\,(0.62)\,(5.5)} = 0.003 \text{ in.}$$

ORIFICE METHOD

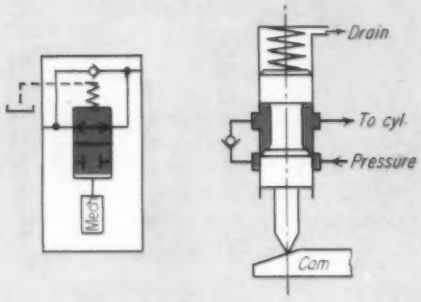
Orifices in the cylinder wall, rather than annular clearance, can serve as the restriction, Fig. 3. Flow resistance increases in steps as the piston covers each hole, and



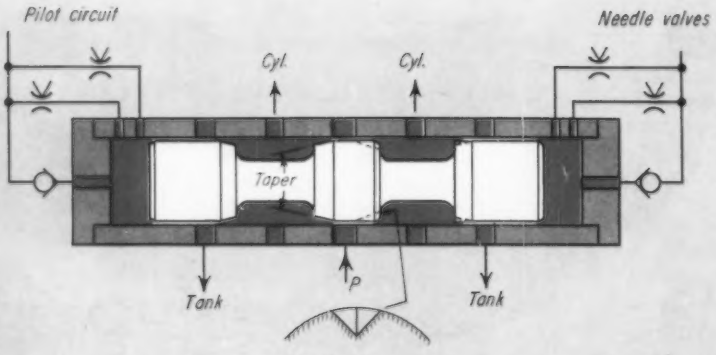
4 Open binary . . .
dashpot reduces force of oil pressure against piston at end of stroke because outer piston *A* hits stop *E* and only area of *C* is effective.



5 Caged binary . . .
dashpot works same as open binary: Outer piston reaches end of travel first, and inner piston completes travel at reduced force.

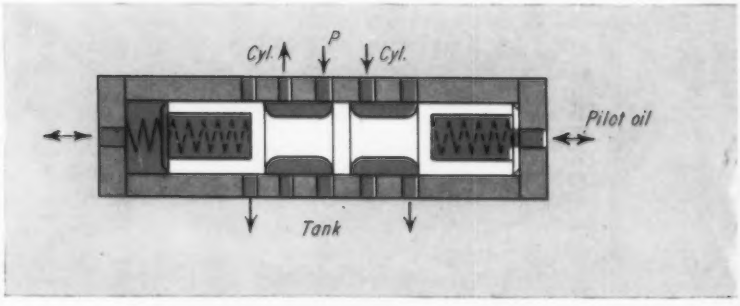


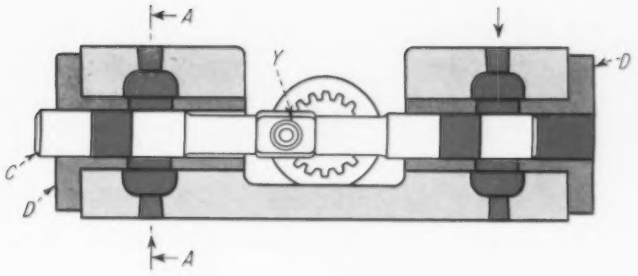
6 Deceleration valve . . .
throttles oil flow to cylinder at will of cam, making possible a variety of velocity-time responses. Cam may be operated by actual cylinder travel.

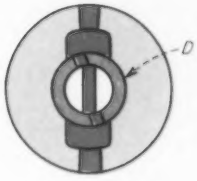


7 Pilot-operated . . .
flow-control valve uses carefully tapered and notched piston to provide accurate restriction for both loading and unloading working cylinder. Also, pilot flow is separately throttled for finer control.

8 Reversing valve . . .
is spring-centered to stop flow in both directions if pilot pressures are zero or equal. Slowness of movement to ends depends on difference in pilot pressure and design of springs.

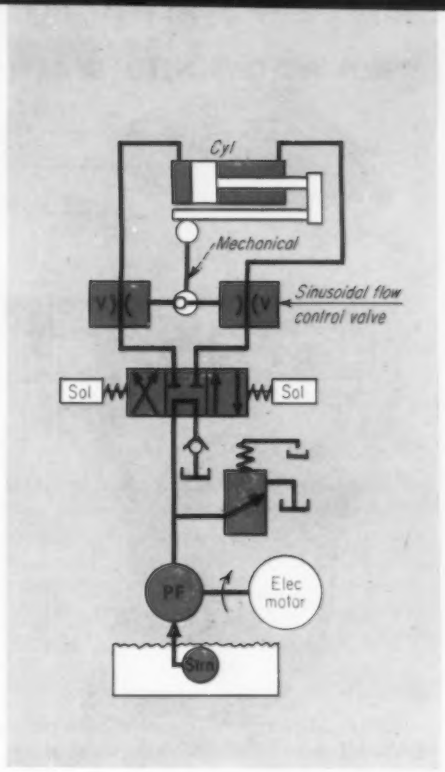




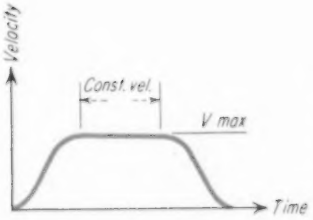


Section A-A

9 Sinusoidal flow-control . . . system uses gear train and hydraulic valve to tie in cylinder piston position with oil pressure, matching sine and cosine curves.



10 Symbolic picture . . . of sinusoidal flow-control (Fig. 9) shows how gears are driven by piston extension to vary valve position and maintain sine-cosine response.



11 Trapezoidal . . . response maintains max velocity at center stroke where needed, yet damping prevents end-of-stroke shock.

decreases in steps as the piston moves to uncover the holes. In the uncovering direction, oil flow is induced rather than pressurized.

Location and spacing of orifices can be used to give a suitable basic displacement curve. Orifice area can be made variable for the purpose of greater flexibility. Hydraulic balance of piston can be attained by arranging orifices in diametrically opposed pairs. When A_P represents piston area and Q_t the total oil input,

$$V_{max} = \frac{Q_t}{A_P}$$

Recalling the equation for orifice flow, $Q = C_D A \sqrt{2GH}$, and assuming that mean pressure differential ΔP is constant then Q is a function of effective portion A_E of total orifice area A_T, hence,

$$V_X = \frac{V_{max} A_E}{A_T} = \frac{V_{max} (A_T - A_A - A_B \ldots)}{A_T}$$

where A_A, A_B, etc., are individual orifice areas.

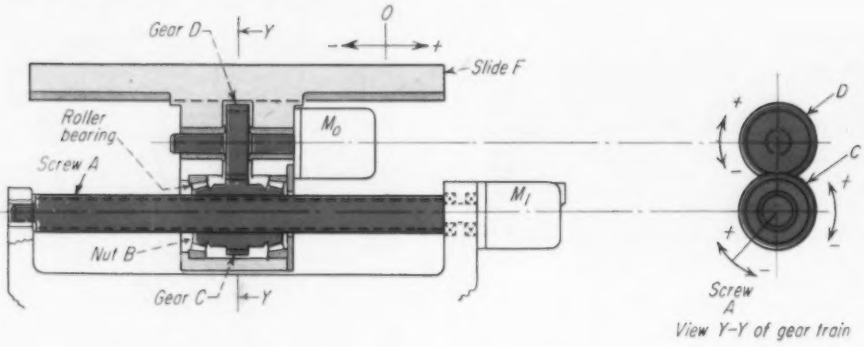
SLOWDOWN WITH BINARY PISTON

The binary piston, Figs. 4 and 5, is a third way to slow down. It is primarily a free-floating piston A, Fig. 4, confined in its movement between collar C and D of piston rod B. Its working cycle differs from that of the conventional cylinder in one important respect. Initially when cylinder is pressurized, piston A will slide until it contacts either collar C or D. Hence, piston rod B will commence to move under full pressure until piston A is stopped by sleeve E. Remainder of the stroke is under reduced power proportional to area of the piston bore; on reversal, the same action occurs, except that the piston-rod area reduces power output further. Binary-piston design meets frequent demands for max power output at start of piston stroke and diminished output at end of stroke. It needs no flow-control device.

FLOW-CONTROL VALVES

Simple deceleration valves, cam-controlled, can throttle the pressure of oil to the cylinder and provide the smooth reversals needed (Fig. 6). The pressure port is normally open to the cylinder and can be closed through cam action, resulting in a desired rate of deceleration at end of stroke. This form of damping works for dynamic loads, and can also interrupt long strokes with periods of dwell at desired intervals by a series of adjustable dogs or cams spaced as needed. Conventional cylinders can be employed.

Piloted flow-control valves, Fig. 7, allow better control of cylinder operation. To avoid abrupt starting, the spool section governing the port openings may be provided with tapered lands or V notches, as shown in the illustration. The smaller the included angle of taper or V notch, the more gradual the flow rate when the spool is shifted. Also, the pilot-operated valve can be made to reverse slowly by metering the oil from pilot circuit through adjustable needle valves. (Turn page)



12 Differential . . . drive is a hydro-mechanical arrangement using the difference in rpm of hydraulic motors M_0 and M_1 to move nut B axially along feed-screw A, and thereby move slide F.

Other ways to dampen movement are available. A spring-centered pilot-operated reversing valve (Fig. 8) attains a measure of damping depending on the ratio of spring power to pilot oil pressure. A coil of small copper tubing is common practice when an inexpensive yet dependable method is required, and when oil volume is not large.

SINUSOIDAL RECIPROCATION

Simple harmonic motion is an example of reciprocation without abrupt variation. Gear mechanisms are available to coordinate the movement of a flow-control valve with a hydraulic cylinder, producing true sinusoidal travel. These mechanisms are designed to match the typical sine-cosine curves where displacement, velocity, and acceleration have sine or cosine response when plotted against time.

The valve spool C in Fig. 9 is actuated by a sine-cosine gear-type mechanism (not shown) which engages the spool at fulcrum Y. Fig. 10 shows how the sine-cosine mechanism can be coupled to a suitable sliding member of the cylinder mechanism, providing the required speed ratio; piston stroke and speed will correspond to linear motion of fulcrum Y. (An alternative is with a feedback system using a timing device that works with a reversing valve in the hydraulic system).

When the mechanism is set in motion, fulcrum Y will describe an oscillatory linear motion matching the cylinder piston motion. The ports of the sleeve D, serving alternately as pressure and exhaust ports, are slots of uniform width, as are the corresponding openings in spool C. The sleeves are individually adjustable for volume control, and timing of the cylinder stroke can be conveniently arranged.

The exposed area of each port is a function of spool displacement and the spool motion is characteristic of the cosine curve; therefore flow Q into and from the cylinder is represented by the area under the cosine curve (in units of velocity and time) multiplied by piston area A_p.

When mean velocity equals unity,

$$Q = A_P \int_0^{2\pi} (1 - \cos X)\, dX = A_p 2\pi$$

For practical reasons, oil pump delivery should exceed by 20% the peak demand of the system. Therefore, stroke length $L = 2\pi$ in., T_s = time of stroke in sec, and required pump capacity is

$$Q_P = \frac{2.4\, LA_p}{T_s} = \text{in.}^3/\text{sec}$$

Oil compressibility, ambient temperature and the variation of the Reynolds number during oscillation have some effect but may be neglected in most problems.

Intermittent gearing can be employed in the drive mechanism of the sinusoidal flow-control valve if shockless reversal in an optimum velocity program, plus a constant feed-rate level, is required. A trapezoidal velocity-time response, for example, may be obtained (Fig. 11). In transfer mechanisms requiring sequential cyclic operation (i.e., total cylinder stroke divided in periodic intervals of dwell and fast operation) the cosine mechanism can be geared to suit. Standard four-way solenoid actuated valves can aid control too.

DIFFERENTIAL DRIVE

The differential hydro-mechanical drive actuator, Fig. 12, offers some advantages not found in conventional feed-screw designs. Machine tool slide F moves in proportion to the sum (or difference) of hydraulic motor movements. Here is how it works.

Zero feed results when both nut B (driven by gear D) and screw A rotate in the same direction and at equal angular velocity. When they rotate at different angular velocities, then the nut will travel axially along the screw, carrying the whole slide assembly (slide, motor M_0, gear D, nut B). It is possible to reverse linear slide motion by a negative or positive change in differential rotation. Furthermore, since the differential causes slide movement, the absolute speeds of the motors can be held near the most efficient range. This avoids low-speed (below 10 rpm) servomotor operation which tends to be erratic.

Velocity-time response is determined by inputs to servomotors M_0 and M_1, and can be varied to suit actuator requirements. Max feed rate occurs when nut and screw rotate full speed in opposite directions, and is twice that in conventional feed-screw design.

EDITOR'S NOTE: The problem of controlling high-force transients in hydraulic cylinder design is given theoretical treatment in "Transient Repsonse of Hydraulic Actuators," Apr '57, p 175. Louis Dodge, author of the article in this issue, explains valve response in "Calculating Time Lag of Hydraulic and Pneumatic Valves," June '56, p 158.

Progress in design . . .
dial at left was shadowed by overhanging cover.

9 ways to . . .

MAKE INSTRUMENTS READABLE

An instrument is only as good as the accuracy and speed with which optical conditions allow you to read it. Here are nine conditions that cause trouble—and ways to get around them.

R. M. ROWELL
Instrument Dept.
General Electric Co.

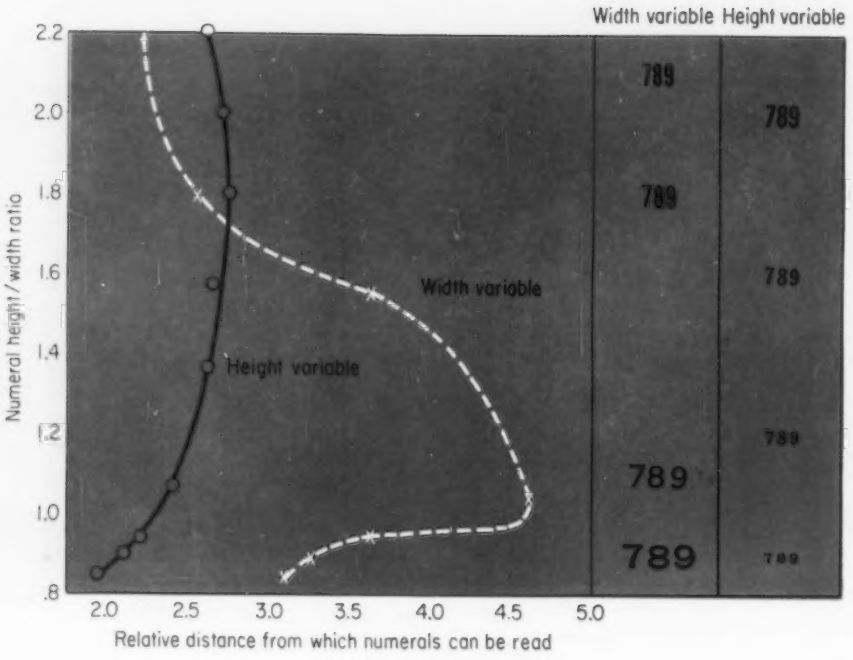
TRY reading your wrist watch at a distance of two feet and an angle off the perpendicular. Even with eye-strain you won't get a quick, accurate figure. The problem of reading instruments becomes more serious, and errors more costly, when a pilot works in a darkened cockpit, an engineer cranes up at a test panel, or a machine operator leans over to read a speed indicator. It's a problem that can be broken down into several elements—and there are one or more solutions for each.

Here is a check-list covering common troublemakers that can lower the visual efficiency of an instrument. Improved lighting conditions are, of course, the first consideration when meters and indicators must be read fast and correctly under less-than-optimum conditions. But drawbacks such as shadows, glare, and parallax can be overcome, too, if proper attention is given to design and selection of instruments.

ILLUMINATION

1 **Quantity of light** thrown on the instrument underlies all other considerations. An intensity of at least 30 foot-candles is recommended. Lighting instruments internally works when ambient illumination must be kept to a minimum, as in locomotive cabs. But this answer is not recommended for control rooms because it induces eye-strain and because internally lit instruments are hard to illuminate uniformly. Ceiling luminaries of the egg-crate type are particularly effective for readability. So are lamps behind broad panels of diffusing glass.

2 **Shadows** thrown on instrument scales black out calibration lines; in extreme cases, even the numerals lose readability. The shadows may result from spotty illumination, from overhanging covers on the instruments themselves, or from intervening levers, knobs or other



Height-width ratio . . .
determines readability of instrument scale. When numeral height is fixed, varying widths show 1:1 ratio is best. With width kept constant, comparison gives best results when ratio is 1.8:1.

control parts. Projecting devices above instruments may cast shadows on the dial. Those shadows cast by overhanging bezels or covers will vanish if instruments having scales mounted flush with cover surface and curved windows are used; even when light strikes the instrument at sharp angles, the scale will be brightly illuminated. Such instruments are now available.

3 **Glare** comes from nonuniform illumination. Lighting from windows and concentrated artificial lighting are notable troublemakers. They cause the instrument cover-glass to pick up reflections that give intense glare spots which obscure calibration lines and numerals. Uniform illumination is, of course, the best answer. But even when lighting is nonuniform, glare can be reduced by a light chemical etching of the glass surface. This treatment, carefully applied, will eliminate most of the glare–without impairing transparency.

SCALE DESIGN

4 **White scales** now represent a large proportion of all instruments produced. This is not just whim. Tests by the Armed Services and other agencies show that white scales with black markings are easier to read than black scales with white markings.

5 **Distracting influences** are a major enemy of quick readibility. Markings that do not contribute to accuracy should be moved from the scale to some other part of the instrument. A good way to handle information that must appear on the face but is not necessary for accurate readings is to hide it under the cover in corners of the scale. Visible data should be limited to calibration lines, scale numerals, and legend defining the quantity to be measured. Manufacturer's name or insignia, commonly placed on the scale, should be of minimum size. Markings and circuit labels should be on the panel, below or adjacent to the instrument.

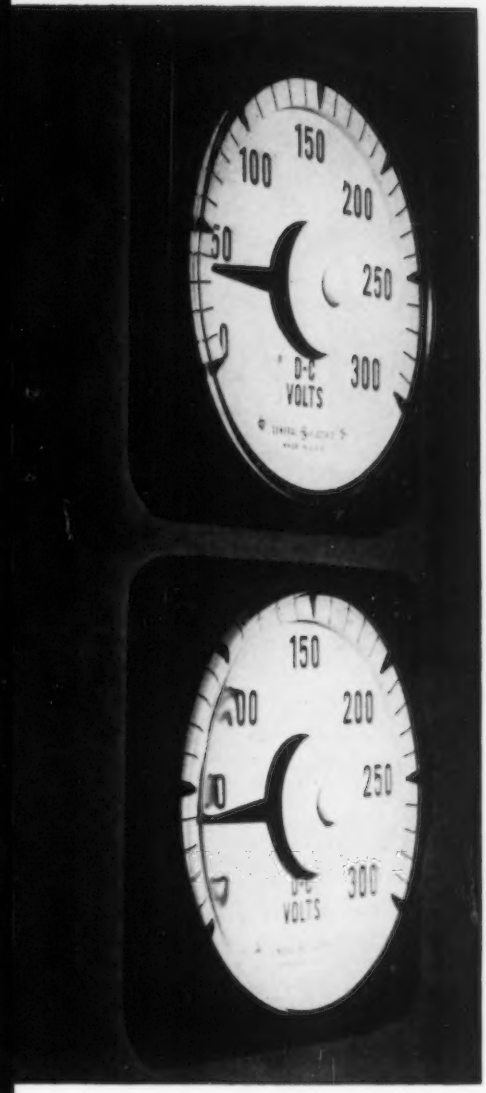
THE NUMERALS

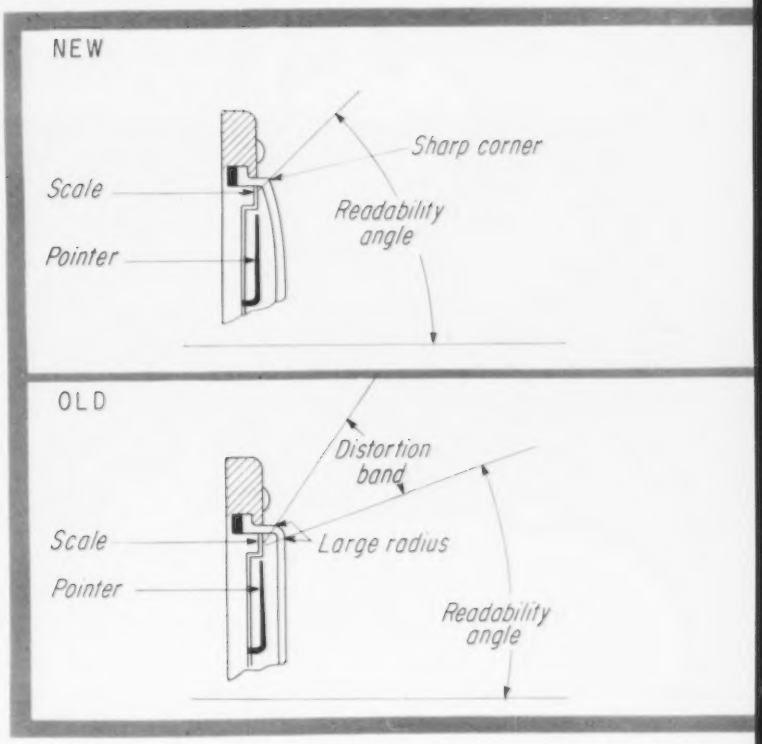
6 **Position** of a scale numeral is important. It must be clearly associated with only one major calibration line–not confused with adjacent lines. Centering the numeral with the calibration line is the best answer. But even this may give confusion when a numeral with several digits spans almost an entire major division. An effective cure is to accent the major division lines for prompt association of numeral with corresponding line.

7 **Best size and shape** of numerals for readability is controversial. One research paper recommends numerals with a height-width ratio of about 1:1. This works when a digit stands by itself. But each scale design should allow for the maximum number of digits, and such broad figures, when adjacent to each other, often cause interference because of the crowded appearance. Result is that a broad numeral, if used, must be reduced in size considerably–at the expense of readability.

A more practical way to decide numeral size concentrates on total available spacing. For any particular scale, the number of divisions, consequently the space between them, is easily determined. The problem then becomes one of marking a given number of numerals for maximum readability in a given space.

The solution has been indicated by tests with a variety





Optical distortion . . .
occurs (below) when scale must be read at extreme angles through rounded corners of instrument cover-glass. Cure (above) in newer model is sharp corner at a point closer to scale.

of type faces. They were approximately the same width, with normal spacing, but with varying numeral heights. It was then found that maximum readability occurred at a height-width ratio of 1.8:1. A government study of readability concurs closely with this conclusion. It also recommends a "stroke width" (breadth of line forming the numeral) of $\frac{1}{6}$ to $\frac{1}{8}$ the height of the numeral. Moreover, straight-sided figures of uniform width are much easier to read at marginal distances than those with nonuniform sections.

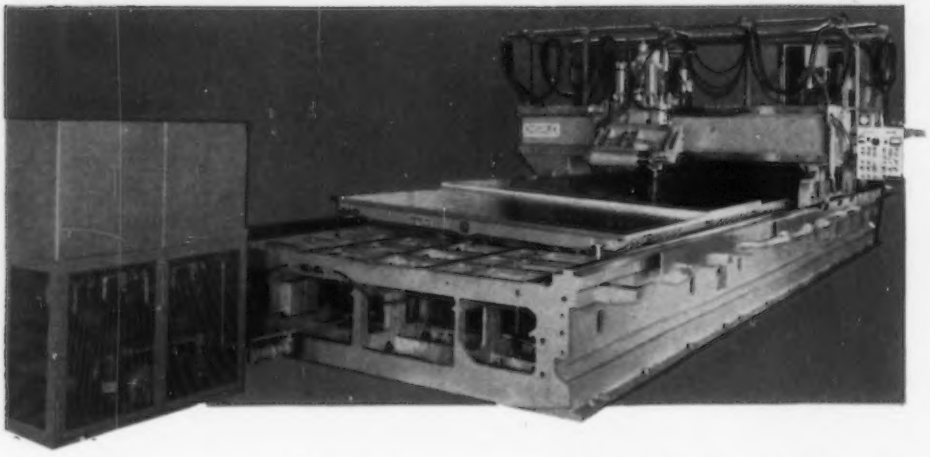
OFF-AXIS READINGS

8 **Parallax errors** come in when an instrument must be read at a sharp angle rather than perpendicular to the scale surface. This trouble is cured by using so-called "anti-parallax" scales—their calibration lines are on a raised step that brings them level with the pointer and eliminates errors caused by off-axis readings.

9 **Distortion** by the instrument window, when reading is at a sharp angle, can be as troublesome as interference from adjacent instruments and projecting covers. A flat glass window gives minimum optical distortion but requires the scale to be placed at some depth below the cover surface—and this limits the observation angle. Another solution is to mount the scale flush with the cover bezel and use a dome-shaped window. Now the bezel no longer interferes with vision. But curved glass may cause optical distortion.

This problem is attacked by sharply changing contour of the glass so that it can still be clamped inside the narrow bezel while, at the same time, clearing the scale. One approach is with a flat window and a rounded 90° corner at the perimeter. But considerable distortion occurs when readings are made through the rounded corner. To avoid this, the window contour should break sharply at a point outside the scale diameter, and drop straight down inside the bezel. This sharp break is made closer to the scale than with a rounded corner, but a slightly convex surface gives ample clearance between meter mechanism and window.

EDITOR'S NOTE: Further information on instrument readability, types and causes of reading errors, scale numbering, and zero-point location will be found in "Obtaining Readability in Instrument Dials," Apr., '50, p 109. Also, "Designing the Products to Suit Human Dimensions," Sept., '55, p 167 discusses various average human dimensions, including vision angles and distances.



Linkage Keeps Table Flat

Sine table for large vacuum chuck rests on center trunnions and differential links spaced along its sides. The synchronized links adjust table to compound angles, keeping all points in one plane—so that table flatness no longer depends upon its stiffness.

Table and chuck are 24 ft, 2 in. by 10 ft, 2 in., and were made by O. S. Walker Co., Worcester, Mass. The assembly is used with skin mill made by Onsrud Machine Works, Inc., Niles, Ill.

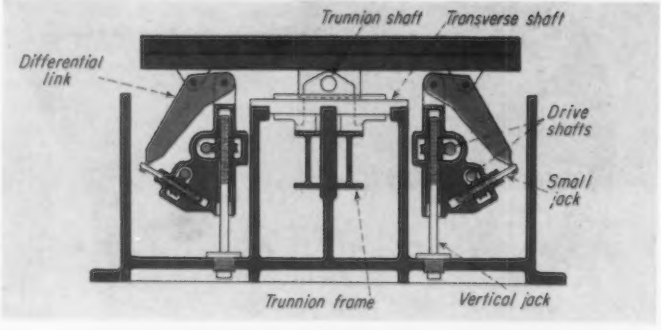
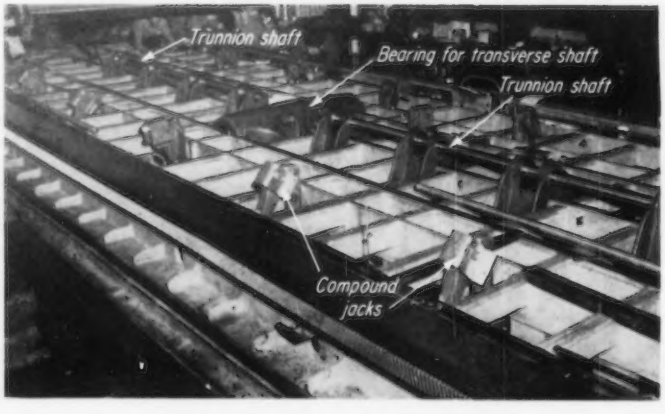


Table is supported . . .

a ong center on trunnion shafts; along sides by jacks that position differential links. Frame supporting the trunnions pivots on center transverse shaft. Differential links along table edges carry over half the weight of table, chuck and workpiece; are positioned with preloaded micrometer jacks that have a common drive.

The compound jacks form two positioning systems: One controls longitudinal tilt; the other controls transverse tilt. Vertical jackscrews along each side move through equal increments, tilting table about long axis. Those on one side move up while those on opposite side move down. Small jacks are connected to long link arms and control tilt about transverse axis. Jacks at table ends move twice as far as intermediate jacks for a given adjustment. There are no links at jacks in line with transverse shaft.

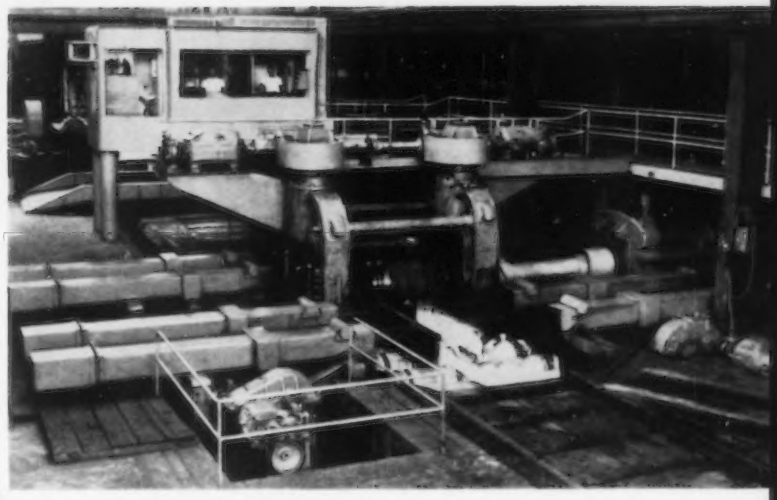
Table tilts 3° about long axis and ½° about short axis. Position is indicated by revolution counters calibrated in 0.0005-in. increments of vertical displacement.

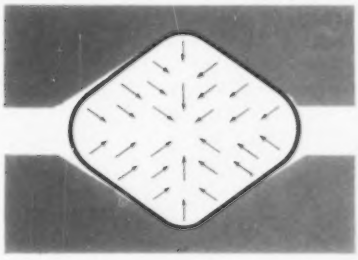


This Mill Rolls Superalloys

Grooves in rolls are diamond-shaped, giving improved grain structure by kneading hot material toward billet center. Results: mill squeezes 18-in. superalloy ingots into 3-in. billets.

First of its size to roll superalloys and highspeed steels, the 32-in. cogging mill was designed by Latrobe Steel Co., Latrobe, Penna. Steels rolled include 18-4-1, M-2, M-3 and T-15 tool steels, and their sulfurized modifications; high carbon, high-chrome die steels; and Waspalloy, M-252 and Udimet 500 vacuum-melted nickel-base alloys.



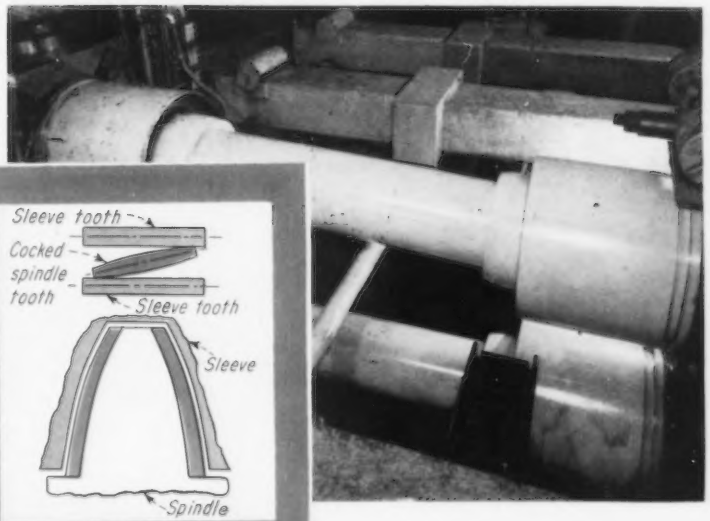


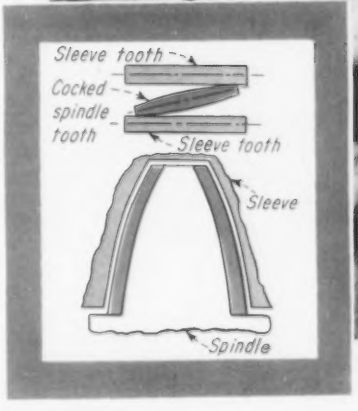
Mill solves problem . . .
of rolling difficult-to-work steels without damaging their crystal structure. Up to now, tough metals had to be shaped into bars with forging hammers. Blooming mills were unsatisfactory because their box or flat rolls often ruptured centers of hard-steel ingots—lateral flow at billet center could not be restricted.

New mill gives more uniform structure in less time. Diamond-groove rolls press in and deform ingot uniformly, compacting and refining center grain structure.

High-torque drive . . .
has spindle couplings that absorb misalignment when opening between rolls changes for different reduction rates. Couplings transmit 960,000 to 5,000,000 in.-lb torque at 63 to 190 rpm and are largest ever made of this design. Misalignment can be 4°50′, much more than the ½° of standard couplings.

Coupling spindles have curved involute tooth faces to get extra misalignment with little backlash, give constant angular velocity at the drive rolls. Coupling sleeves have straight teeth. Curved spindle-tooth form is generated on a gear shaper and has a straight pitch line. When spindle tooth is cocked in sleeve, line of contact is always an involute matching curve of sleeve tooth. Coupling was made by Metal Products Div. of Koppers Co.

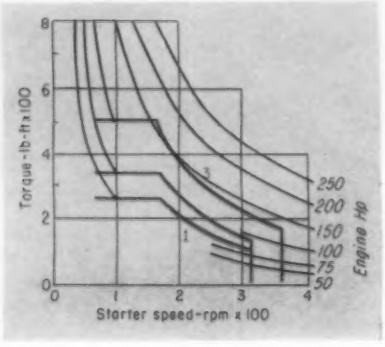


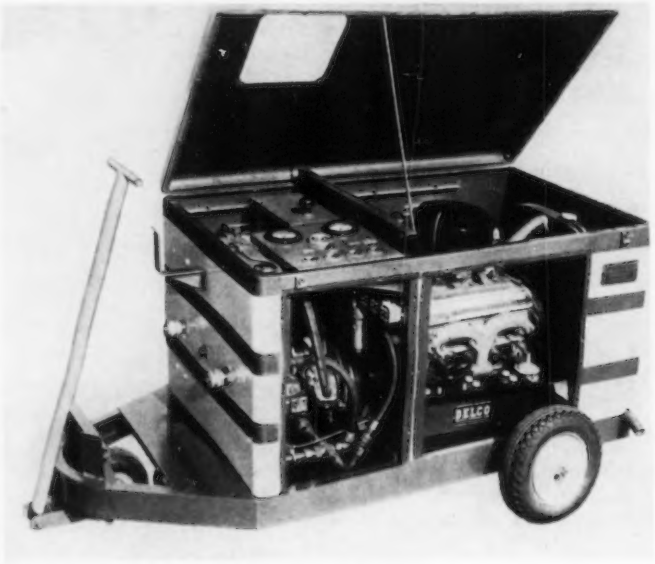


Starter For Turbo-engines

In US—Hydraulic

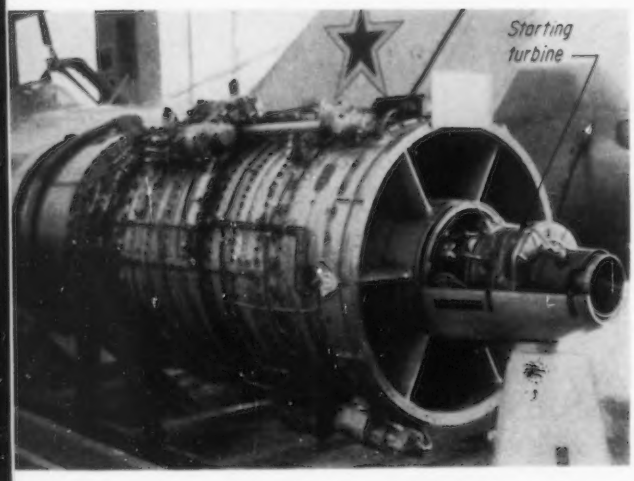
Fluid power links gasoline and turbo-engines in this Vickers Inc. ground power unit, matching torque and speed characteristics for fast starting. Pumps and motors are selected for each application to get lowest weight and engine hp.





Variable displacement pump . . . drives two hydraulic motors connected to a single gear box; valving cuts out one motor at half the starter cutout speed. Constant torque at low speed is set by motor size, system pressure and gear ratio, but performance follows power limit curve as starter accelerates. Best system is selected by analyzing plots of torque, power and cutoff speed versus time.

In USSR—Gas Turbine



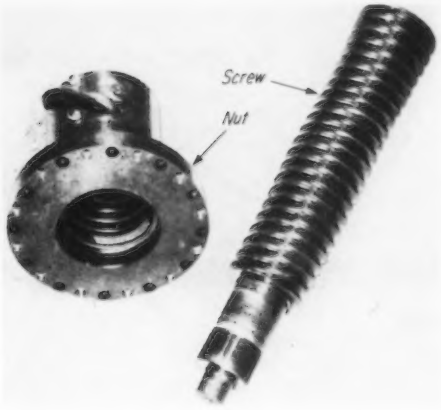
Small turbine starts Russian AM-3, 15,000-lb-thrust turbo-jet engine that powers TU-104 aircraft. The radial-flow starter turbine is brought up to speed by an electric motor and delivers 60 to 100 hp at top speed. Jet engine and government bureau that designed it are named for designer A. A. Mikulin.

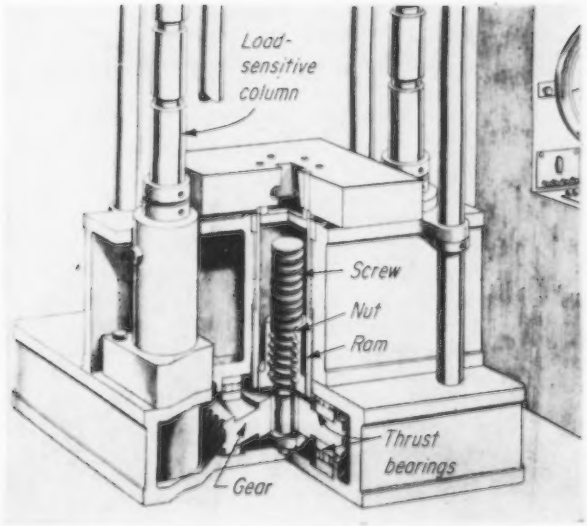
Engine is simple design . . . with outside casing dia of 48.5 in. An 8-stage compressor is followed by an annular combustion chamber with 14 fuel injection nozzles and 56 gas nozzles. Main turbine has one stage with wide blades; compressor blades, too, are thick and wide. Main bearings are in front, middle and turbine frames; turbine wheel is outboard. Aluminum compressor casing is split axially and radially, and alloy-steel combustion chamber is only 25 in. long. Specific fuel consumption is about 0.9 lb per lb thrust per hr. Data was obtained by B. M. Miller, Jr. and R. E. Stockwell of General Electric Co. on visit to Moscow air show.

Ball Screw Speeds Cycling

A preloaded ball screw replaces acme thread in fatigue-tester drive, allowing smaller motor to cycle specimens at higher frequencies. With 150,000-lb capacity, machine is largest single-screw mechanical tester.

Tester has strain gages that measure tension, compression or loads that cycle through zero. It was developed by Electronics and Instrumentation Div. of Baldwin-Lima-Hamilton Corp., Waltham, Mass.



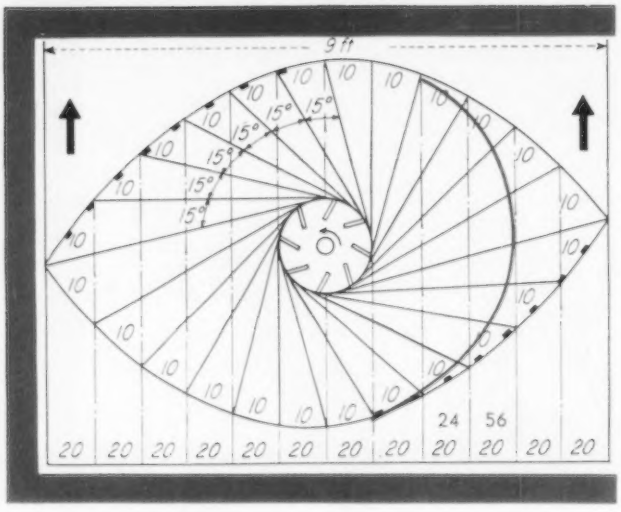


Preloaded drive . . . avoids drift caused by loss of lubricant in screw clearances. Pitch lines of screw and nut are displaced to preload balls, and threads of screw are ground for constant preload over its 30-in. length. It is driven by a 30-in.-dia gear carried between roller thrust bearings that are preloaded to machine's capacity. This reversible drive has an electric clutch-brake to hold load which is measured by SR-4 cells in columns. Efficiency of 6-in.-dia ball screw (90% to 95% vs 25% to 30% for acme thread) reduces required motor hp from 15 to 5.

Hood Spreads Fertilizer Evenly

An ellipse-like folding hood is the feature of this fertilizer spreader. It catches the plant food thrown from a rotating disk and scatters it evenly over a 9-ft path.

Spreader mechanism includes a grinder that crushes lumps and mixes various fertilizers before feeding them to the disk. Spreader covers 100 acres per day, is made by Martin Rausch Landmachinenfabrik, Marburg, Germany.



Shape of hood . . .
and varying the disk speed to match trailer speed keeps spreading rate constant. Material thrown from each 15° sector of disk is scattered by hood over a different strip of land. Numbers in diagram give relative amount deposited in each strip. Note heavier deposit in outside strips if hood is circular. Skirt on hood prevents wind from affecting distribution. Disk is driven at 540 rpm by trailer axle through bevel gears.

Hood comes apart . . .
in four pieces, two of which are hinged side sections that fold against trailer for storage. Hood is made of stainless steel, to resist the corrosive effects of most fertilizers.

Drop-hammer bounces . . .
as technician yanks test panel off anvil after first impact.

Participating Organization	Function
Owens-Corning Fiberglas Corp.	Sponsor
Gibbs & Cox, Inc.	Engineering development
Bellingham Shipyards Co.	Fabricator
Glasspar Co.	Fabricator
Lunn Laminates, Inc.	Fabricator
Zenith Plastics Co.	Fabricator
Cornell Aeronautical Laboratory	Qualification tests
Massachusetts Institute of Technology	Testing
National Bureau of Standards	Testing
New York Naval Shipyard	Testing
Picatinny Arsenal, US Army Ordnance	Testing
The Budd Company	Impact testing
University of Dayton Research Center	Data processing
Forest Products Laboratory	Advisory

FOURTEEN ORGANIZATIONS FORM TEAM TO SET RELIABILITY STANDARDS FOR

fiber-reinforced plastics

A five-year program, set up by Owens-Corning Fiberglas to uncover basic design data, has these features:

FORD R. PARK
Associate Editor

- FIVE EXPERIMENTS TO COVER 6 VARIABLES
- GRAECO-LATIN SQUARE ANALYSIS TO MAKE EVERY TEST COUNT
- STATISTICAL DATA ANALYSIS FOR KNOWN CONFIDENCE LIMITS
- DATA ORGANIZED FOR COMPUTER CORRELATION
- FUTURE DATA EASILY INCORPORATED

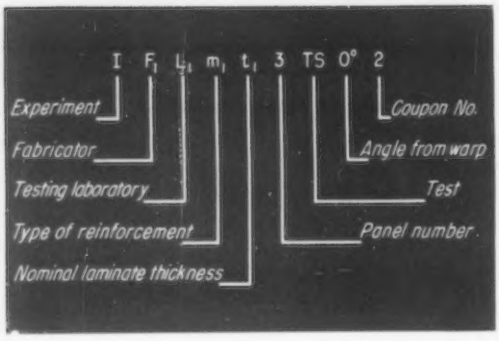
Research and development is aiming a new, piercing look at fiber-reinforced plastics. Led by Owens-Corning Fiberglas Corp., 14 organizations set out recently to establish standards of reliability and obtain design data that will encourage extending these materials into untried areas.

In the program are various R & D labs, government agencies, a data processing center and fabricators who, like Owens-Corning, have a direct stake in the future of these plastics, but do not have the funds, time, equipment or knowledge to do the job individually. The testing is expected to run at least five years. Results are expected to give designers higher-performance data—without need for expensive test programs on their own.

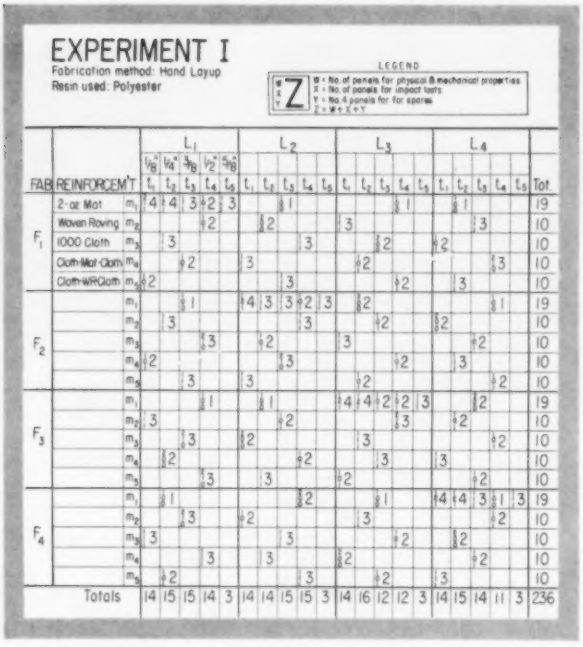
Data will be carefully grouped in statistical patterns that will provide a common basis for obtaining and presenting engineering information on these materials. In addition, the industry at large will be able to contribute comparable information from its own development work.

Big push behind the program has been the need to build greater engineering and manufacturing confidence in fiber-reinforced plastics. Even though the material is appearing in more and more high quality applications, sufficient data has been lacking on mechanical properties. More must be known about the influence of geometry, composition and manufacturing technique.

Conceived as an investigation into the potential of these plastics for marine structures, the present study is an extension to all aspects of structural design, and



1 Coding system . . .
for test panels simplifies cross-correlation of variables by computer.


EXPERIMENT I
Fabrication method: Hand Layup
Resin used: Polyester
LEGEND
Z: W = No. of panels for physical & mechanical properties; X = No. of panels for impact tests; Y = No. 4 panels for for spares; Z = W + X + Y

FAB	REINFORCEMENT		L$_1$ 1/8" t$_1$	L$_1$ 1/4" t$_2$	L$_1$ 3/8" t$_3$	L$_1$ 1/2" t$_4$	L$_1$ 5/8" t$_5$	L$_2$ t$_1$	L$_2$ t$_2$	L$_2$ t$_3$	L$_2$ t$_4$	L$_2$ t$_5$	L$_3$ t$_1$	L$_3$ t$_2$	L$_3$ t$_3$	L$_3$ t$_4$	L$_3$ t$_5$	L$_4$ t$_1$	L$_4$ t$_2$	L$_4$ t$_3$	L$_4$ t$_4$	L$_4$ t$_5$	Tot
F$_1$	2-oz Mat	m$_1$	4	4	3	2	3			1						1			1				19
	Woven Roving	m$_2$				2			2				3							3			10
	1000 Cloth	m$_3$		3							3				2			2					10
	Cloth-Mat-Cloth	m$_4$			2			3						2							3		10
	Cloth-WR Cloth	m$_5$	2							3						2			3				10
F$_2$		m$_1$			1			4	3	3	2	3		2							1		19
		m$_2$		3							3				2			2					10
		m$_3$				3			2				3						2				10
		m$_4$	2							3						2			3				10
		m$_5$			3			3						2							2		10
F$_3$		m$_1$				1			1				4	4	2	2	3		2				19
		m$_2$	3							2					3			2					10
		m$_3$			3			2					3							2			10
		m$_4$		2							2			3			3						10
		m$_5$				3			3				2							2			10
F$_4$		m$_1$		1							2			1			4	4	3	1	3		19
		m$_2$			3			2					3							2			10
		m$_3$	3							3					2			2					10
		m$_4$				3			3				2						2				10
		m$_5$		2							3				2			3					10
Totals			14	15	15	14	3	14	14	15	15	3	14	16	12	12	3	14	15	14	11	3	236

2 Graeco-Latin Square . . .
analysis cuts required tests by 75% and monitors 236 test panels in one chart. Test program was devised by John Gibbud of Owens-Corning and John Leigh of Gibbs & Cox.

embraces five broad experiments covering these four major variables:

- **Fabricators—effect of variations in good shop technique.**
- **Laboratories—effect of variations in testing techniques and equipment.**
- **Materials—effect of different types of reinforcement in the plastic.**
- **Laminate thickness—effect of number of reinforcement plies.**

The program will examine how these influences interact with two other variables–the common base resins and processes used in making fiber-reinforced plastics.

ENTER STATISTICS

For the proposed five experiments, a total of 7625 tests will be run on samples cut from 587 fabricated panels. This represents only a fraction of the tests originally contemplated. As the program evolved, over 30 significant variables were examined, and the need for statistical analysis became apparent. For example, in Experiment I (Table, opposite page) all combinations of the five thicknesses, five reinforcements, four fabricators, and four testing laboratories gives 400 constructions. To this add sufficient duplicates of each to insure statistical accuracy, and you need 960 panels, involving the manufacture and testing of over 4 tons of fibrous glass panels, 20 in. square.

If certain laws of distribution and replication are obeyed, a statistical array of desired values can be closely approximated by taking only a small fraction of the apparently required data. The Latin Square and its more sophisticated descendent, the Graeco-Latin Square, accomplish just this. The latter brings more variables under control, and with only the square root of the number of measurements required by complete evaluation of all combinations of the variables. Graeco-Latin Square analysis in Experiment I has reduced panels required from 960 to 236–less than 1 ton of material is needed.

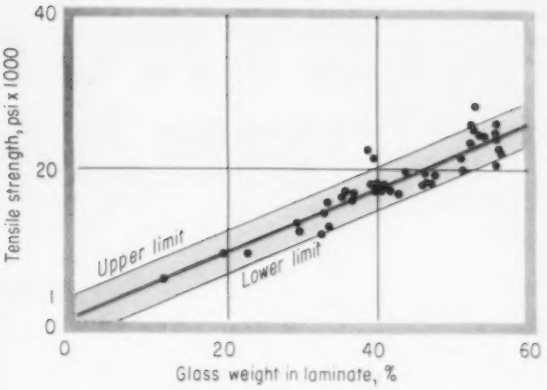
Before a Graeco-Latin Square tabulation can be devised for a particular experiment, the basic properties to be tested must be selected. In the R&D program, about 18 different physical and mechanical properties are to be found and recorded for each construction. Many will be determined in the three directions, 0°, 45°, 90,° because few laminates are isotropic. Test samples, over 3000 of them for Experiment I, are laid out with stencil patterns on the 20-in. panels.

To keep track of panels and coupons, a special coding system has been devised, Fig. 1. This permits the panels, their assigned fabricators and testing laboratories to be summarized and monitored on a single chart, Fig. 2. Adding three more designators–for the test performed, angle from the warp, and sample number–permits each coupon to be clearly and functionally identified. Each sample with its coding is then assigned a number which is recorded both on the test panel and in a master record book. A typical panel for Experiment I, stenciled and ready for cutting, is shown in Fig. 3.

The code system allows rapid separation and analysis of the data by groups–materials, thicknesses, testing labs, fabricators and other factors or any combinations thereof. The method is especially adaptable to the electronic sorters and computers at the participating University of Dayton Research Center. Raw data will be compiled from punch cards on computers, in the form of tables of sums, products, squares and other data for statistical analysis.

Tables prepared by the computer will also include averages, ranges of main variables, and first-order interactions. For example, Experiment I on the hand layup method will yield 288 tables showing main variable

3 Test panel . . .
stencilled for 42 test coupons. Code (inset top right) tells fabricator, test lab, reinforcement and thickness.



4 Design limits . . .
make fiber-reinforced plastics a true engineering material when established to a known degree of confidence by statistical analysis. Here envelope encloses 95% of tensile strength scatter.

TEST PROGRAM HAS FIVE PARTS

Experiment	I	II	III	IV	V
Fabrication methods	Hand Layup	Hand Layup	Vacuum bag Pressure bag Autoclave	Matched Metal Dies	Matched Metal Dies
Reinforcement materials	2-oz mat Woven roving 1000 cloth Cloth-mat-cloth Cloth-WR-cloth	1½-oz mat 3-oz mat 1044 cloth Cloth-WR-cloth 181 cloth 143 cloth	2-oz mat Woven roving Cloth-mat-cloth	1½-oz mat 2-oz mat 3-oz mat	Fully loaded unidirectional
Resins	Polyester Epoxy	Polyester Epoxy	Polyester	Polyester Epoxy Phenolic	Not yet determined
Thicknesses	5	3	3	3	3
Fabricators	4	2	3	3	3
Test labs	4	3	3	3	3

interactions that are classified thus:

- **Lab vs Fabricator**
- **Lab vs Reinforcement**
- **Lab vs Thickness**
- **Fabricator vs Reinforcement**
- **Fabricator vs Thickness**
- **Reinforcement vs Thickness**

6 x 48 properties = 288 tables

Added to these will be 48 tables of individual properties, and 48 tables of standard deviations for a total of 384 tables of statistical information.

After data is statistically correlated and curves are drawn by least-square methods, scatter of the data will be studied so that envelopes can be drawn around each curve to the desired degree of confidence. In Fig. 4, for example, the influence of glass content on tensile strength has been statistically studied (based on data from the literature) and such an envelope drawn.

This procedure will be followed for all five experiments. Various techniques for making laminates, various resins, other reinforcements, plus new developments such as preloaded reinforcement will be studied to benefit the industry. Result will be confidence in test data that will help designer and fabricator come up with improved products made from a proven material.

TESTS WILL DETERMINE THESE PROPERTIES

Specific Gravity

Ignition Loss

% Glass by Weight

Water Absorption

Barcol Hardness

Tensile Strength and Modulus (0°, 45°, 90°)

Flexural Strength and Modulus (0°, 45°, 90°)

Compressive Strength and Modulus (0°, 45°, 90°)

Poisson's Ratio on all tensile and compression tests

Bearing Strength (0°, 45°, 90°)

Shear
a. Perpendicular (0°, 45°, 90°)
b. Parallel (0°, 45°, 90°)
c. Interlaminar (0°, 45°, 90°)
d. Modulus by plate twisting

Impact on 20-in.-sq. panels

Panel thickness, number of plys and unit weights

Additional tests to be made on fatigue, creep, and stress rupture, using the spare panels

INSTRUMENT BEARINGS for

Here is what happens to ball bearings operated above 300 F, and how special materials and lubricants will reduce or eliminate obstacles to good performance.

At the time Mr. Sinclair prepared this article he was Bearing Development Engineer for New Hampshire Ball Bearings, Inc. He is now Metallurgical Project Engineer with New Departure Division of General Motors Corporation. Here he is conducting special research that continues his interest in improving the life of ball bearings.

When is "too hot"? For a standard catalog bearing, it's generally around 300 F. This is when to start specifying one or both:

- Special lubricants—or even no lubrication at all in certain applications.
- Special materials for bearing rings and ball retainers.

Naturally, high-temperature lubricants should be the first consideration. But not all situations can be solved so simply—and this is where special bearing materials are called for.

What are the limitations of a standard bearing? Very likely, the rings and balls are stainless steel 440C tempered to 400 F after hardening. Ball retainer (or cage) is stainless steel 302. Lubrication is with a synthetic-type instrument bearing grease. Here is what happens as operating temperature goes above 300 F:

UP THE TEMPERATURE LADDER

In the 300 to 500 F range oil evaporates from the grease rapidly and grease structure is changed by oxidation and polymerization. This results in the adherence of a dark, hard resinous film to the raceways.

Hardness and strength of the rings and balls remains fixed up to the tempering point for the material. Above 400 F softening begins, and the yield point goes down progressively with increasing temperatures.

Structure changes occur as temperature is increased. One component in the steel is austenite, which has a face-centered cubic crystalline structure and the greatest comparative density. Another is martensite, with a tetragonal structure and lower density. The third is ferrite; its density lies between the other two. Relative amounts of these components changes with temperature, causing slight changes in volume of the material. These changes in turn lead to distortions and changes in the dimensions when the bearing is successively heated and cooled during its operation. These changes are not ordinary thermal expansion which is normally much greater.

At 750 F the impact resistance of 440C stainless steel is significantly lowered, and may be of concern in some applications.

At 800 F the 302 stainless steel retainer begins to lose some of its corrosion resistance because of intergranular corrosion. For the 440C material this loss begins at 850 F.

At 900 F a slight degree of secondary hardening occurs because of precipitation of chromium carbide from 440C stainless steel. This increases the hardness from RC55 to RC56. Above 900 F the material softens and loses strength rapidly.

At 1400 F the 440C material oxidizes severely and a heavy scale is produced on all surfaces.

PERFORMANCE GOES DOWN

The serious effects caused by rising temperatures are reflected in the way the standard bearing performs.

First affected is the lubricant. Normally, it carries away some of the intense heat generated at the points of contact. It also helps distribute some of the load between the surfaces because its viscosity increases under pressure. But after the lubricant has broken down, the bearing begins to wear rapidly and bearing friction is increased.

Decrease in material hardness reduces wear life of the bearing, while a reduction of the yield strength lowers the fatigue limit and the amount of static load which the bearing can withstand without objectionable permanent deformation: Consequently, both dynamic and static capacity of the bearing are lowered.

Warpage caused by structural changes increases the friction torque and noise level of the bearing.

Thermal expansions of the inner and outer rings cause changes in the radial play of the bearing, and give excessive clearances between the ring and its shaft or housing.

With severe corrosion, bearing life will be decreased, friction and noise will go up.

A standard stainless bearing can be operated at temperatures as high as 900 F if the application is not severe or critical. It is advisable, however, to remove the lubricant if the bearing is operated above the temperature limit of the lubricant.

300 F and up

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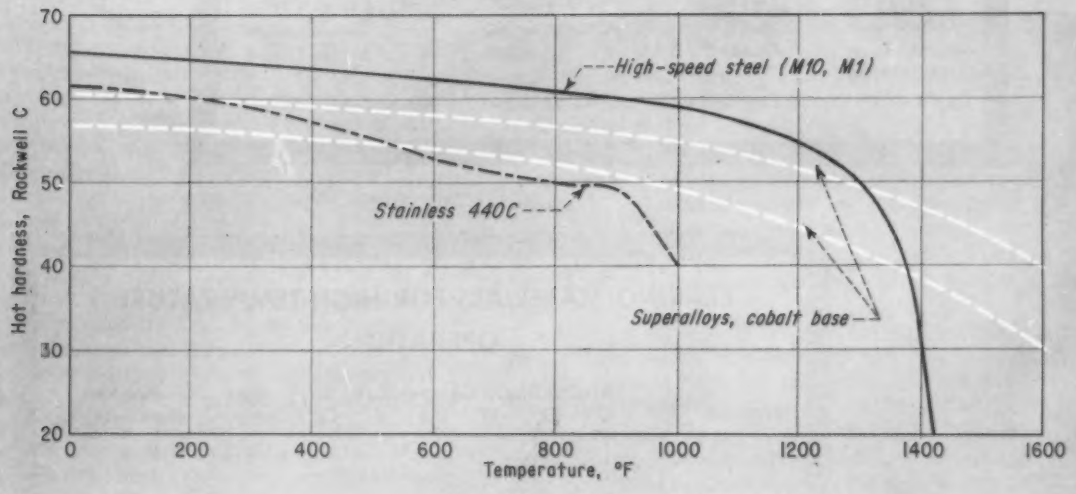


Loss of hardness . . .
with increasing temperature for some bearing materials. High-speed steels are superior to superalloys except at very high temperatures.

IMPROVED BALLS AND RINGS

Stainless 440C. If the bearing is operated without a lubricant, and impact and corrosion resistance are not important for the given application, the only two troubles will be metallurgical instability and softening. The material can be stabilized by specifying a special heat treatment prior to the grinding operations. This treatment can be a triple tempering operation at a temperature approximately 50 F above the anticipated operating temperature.

Little can be done to reduce softening. Stainless steel is relatively soft at high temperatures, has a short fatigue life, and cannot sustain high loads without permanent deformation.

High-speed steels take heavier loads and have greater fatigue life, wear life, and resistance to permanent deformation than the stainless groups. Two promising grades are molybdenum M1 (8-2-1) and M10 (8-0-2). When specifying them also specify triple tempering. Upper operational limit for the high-speed steel bearings is about 1000 F. Corrosion resistance is lowered as temperature increases–similar to stainless steel. But even with slight oxidation, bearings will have adequate life at 1000 F.

Superalloys. In the range between room temperature and 1000 F the hot hardness of high-speed steels is superior to that of the superalloys. Above 1000 F, however, hot hardness of high-speed steels drops off far more rapidly than it does for superalloys.

There are roughly three classes of superalloys: highly

INSTRUMENT BEARINGS for 300F and up

THESE LUBRICANTS WORK TO 300F OR HIGHER

Lubricant	Manufacturer	Temp. Range Continuous Operation, F	Type
Versilube F-50	General Electric	−100 to 450	Silicone Fluid
Versilube G-300	General Electric	−100 to 400	Silicone, Lithium Grease
Super Mil-M-40	Standard Oil	− 40 to 450	Silicone, Organic Grease
Unitemp 500	Texas Co.	− 65 to 350	Diester, Sodium Grease
Mil-L-3545			
Texaco 1999	Texas Co.	to 300	—— Sodium Grease
Aero Shell 5A	Shell	to 300	—— Sodium Grease
High-Temp	Sinclair	to 300	—— Sodium Grease
Mil-L-15719A			
DC-44	Dow Corning	− 44 to 350	Silicone, Soap Grease

BEARING MATERIALS FOR HIGH-TEMPERATURE OPERATION

Material	Approximate Composition, % C	Cr	W	Mo	V	Co	Max Temp., F	Min Hot Hardness, R_C
Stainless 440C	1	17					900	50
High speed M1	8	1	2	8			1000	59
Tool steels M10	8	4		8	2			
Superalloys (Cobalt base)	2	30	15			50	1400	50

alloyed iron base, nickel base, and cobalt-base alloys. Most promising from the standpoint of hot hardness are the cobalt alloys; Haynes Metal Cutting Tool Alloys such as Alloy 19 and and Star J-Metal are good ring materials. These cobalt-base alloys are obtainable in small diameters in rod form, and are often considered for instrument bearings. Hot hardness is adequate up to 1400 F.

Because it is difficult to make small balls from cast alloys, Haynes Wrought Alloy No. 25 is recommended as a ball material. It has excellent resistance to oxidation and corrosion up to 1550 F. Dimensional stability is excellent. Room-temperature hardness is about R_C 45.

Cemented Carbides. Both titanium carbide and chrome carbide have superior hardness, wear resistance, and oxidation resistance at 1800 F. The room-temperature hardness is R_A 80 to 90. Like the superalloys, these materials are dimensionally stable. But because of their high fabricating costs, they should be requested only when the extreme temperature is anticipated. Materials get their good hot hardness at high temperatures through the presence of extremely hard intermetallic compounds or carbides. These carbides are present in the material in all phases and make the material difficult to grind.

BETTER RETAINER MATERIALS

Function of the lubricant in rolling contact is not yet well understood; but, for sliding contact, it plays an important part in reducing wear and friction. Most of the sliding occurs between the retainer, and balls and rings. At high temperature, the ball and ring materials suffer from lowered dimensional accuracy and load capacity, and the retainer shows excessive wear. In fact, failures in small bearings are usually caused by

excessive wear of the retainer because they are subjected to high speeds rather than high loads.

Crown or open-end retainers are light in weight and fairly strong. Their shape prevents excessive churning of the lubricant. But with any appreciable wear, a crown retainer is apt to cock at a severe angle–resulting in the jamming of the bearing. Therefore, a bearing with this type of retainer is susceptible to wear failure.

410 stainless retainers give improved wear resistance. They should be hardened to R_c 44. This material is similar to the stainless 440C ring material in that hardness drops off rapidly at 900 F, and there may be metallurgical instability. Instability, however, is not considered serious for retainers. Scaling temperature for this material is 1250 F.

300 series stainless crown retainers are recommended for temperatures above 1250 F. But for better corrosion resistance, specify 321 or 347 stainless. In effect these are 302 stainless–stabilized against intergranular corrosion by the addition of titanium and columbium. Maximum operational limit of these materials is governed by their scaling temperature of 1450 F.

Plastic solid retainers. Laminated plastics, from which the majority of solid-machined retainers are made, generally have an operational limit of 250 to 300 F. Plastics therefore should not be considered as a retainer material for high-temperature bearings. Teflon, for example, has an operational limit as high as 500 F but it does not possess sufficient rigidity for a retainer. Teflon has recently been impregnated in porous sintered bronze. A solid retainer of this material would possess rigidity from the bronze, and low friction and wear properties from the Teflon.

Nickel alloy retainers. There are indications that above 600 F the oxides of many nickel alloys show some characteristics of a lubricant and reduce seizing and wear. The more promising nickel alloys include "S" Monel, "S" Inconel, and Inconel "X". Their approximate temperature limit is 1100 F.

Retainerless bearings. The majority of lightly loaded bearing failures are caused by retainer wear. This problem becomes acute when a lubricant is absent at high temperatures. An apparent solution is to eliminate the use of the retainer in a bearing. One such bearing is the full-complement type–loading grooves are cut into the side of the bearing to enable assembly of the balls into the bearing. This type is limited to very light thrust loads in either direction unless the groove is cut on only one side of the ring, thereby creating a separable ring full-race angular contact bearing. The bearing can then take an appreciable thrust load in one direction.

LUBRICATION AT HIGH TEMPERATURES

Petroleum-base lubricants are generally best choice for high-temperature applications. However, these natural hydrocarbons have an inherent temperature limit beyond which polymerization or chemical breakdown occurs. To extend both the high- and low-temperature limit for lubricants, chemical companies have developed synthetic lubricants such as the silicones and diester fluids. Most synthetic liquid lubricants have an upper temperature limit between 300 and 450 F.

Reducing atmospheres. It is preferable to run a bearing in the dry condition rather than with a lubricant that would form a resinous film at temperatures above its limit. To prevent oxidation, bearings are sometimes run in a reducing atmosphere or in a vacuum, even though the removal of all traces of metal oxide from the surfaces greatly increases the tendency of the rubbing metals to weld. The contacting base metals need to be separated by a film of low shear strength which adheres to base metal. Such films may be mechanically or chemically formed:

Molybdenum disulfide is a mechanically formed film. Small quantities of nearly pure MoS_2 of very small particle size worked into the surfaces of the bearing raceways, lands, and balls give encouraging results. It is difficult to lubricate a crown retainer with MoS_2, and for many applications better results are obtained with a full type bearing. Above 750 F, MoS_2 reacts in air to form an abrasive compound. In vacuum, however, its operating range can be extended to about 2000 F.

Extreme-pressure (EP) additives in lubricants are already common for heavily loaded gears. Here a temperature increase (resulting from the high pressures) causes a chemical reaction between additive and steel. The product is either iron chloride, iron sulfide, or iron phosphide depending upon which additive is used. These reaction products show many of the characteristics, such as low shear strength and adherence to the base metal, of independently added lubricants. In essence then, EP compounds utilize the high temperature to create a lubricating film from within the steel itself.

A freon-gas atmosphere will also cause a film formation. Freon consists of fluorine and chlorine, and the chlorine reacts to form iron chloride as does the chlorine in the EP reaction.

An interesting theory by Goodzeit and Hunnicutt (ASME paper 54-A-611) indicates certain metals do not appreciably weld and seize when in sliding contact with steel. The metals are: silver, cadmium, indium, tin, antimony, thallium, lead, bismuth, and germanium. Conceivably, some of these metals could be diffused into the contact surfaces of ball bearings to provide a temperature-resistant, non-seizing layer.

EDITOR'S NOTE: Besides the lubricants covered in this article, two new silicone fluids have been recently developed by General Electric (Nov 11 '57, p 118). One has good lubricating properties at temperatures up to 700 F, and the other has good oxidation resistance up to 510 F. Both fluids are companions to Versilube F-50.

A high temperature oil, good for continuous operation to 500 F, and for short periods to 600 F, was announced by Lehigh Chemical Company (May '57, p 228.) Designated as Anderol L-825, the oil has double the film strength of MIL-L-7808C. A new solid-film lubricant effective to 600 F with a friction coefficient less than 0.04, was developed recently by Electro-film, Inc. (Nov 4 '57, p 48.)

Another approach to bearing desgin for high temperatures is discussed in:

"Lubricating with Air," Nov 25 '57, p 99. New concept in design of hydrodynamic gas-lubricated bearings leads to practical design charts. Operation of bearings at high temperature limited only by the bearing materials.

now . . CERAMICS THAT BOUNCE

In spring form, sintered alumina can provide elastic action at high temperatures.

R. H. RUDOLPH,

Manager Marketing
Diamonite Products Mfg. Co.

When rectangular helical grooves are machined in a cylinder of fired alumina frit, the result is a synthetic-sapphire spring with good elastic properties up to 1800 F. This method for producing a helix has been economically applied to diameters from about 1 to 4½ in., with square "wire" sections from $\frac{1}{16}$ to $\frac{1}{4}$ in.

Vitreous-bonded alumina has exceptional hardness and compressive strength, but its low tensile strength limits working stresses in spring form. It has good resistance to thermal shock, is a good electrical insulator, and has low thermal conductivity.

These properties, together with retained elasticity, may make high-alumina ceramic springs valuable in high-temperature components like filament supports in vacuum tubes and in high-temperature relays—areas where the springs are being evaluated.

Tests to date have failed to establish a consistent design value for an elastic modulus; but the modulus is little affected by temperature. Tests between 68 F and 1200 F on the $1\frac{3}{16}$-in. diameter springs, where most work has been concentrated, show a constant spring rate of 0.91 lb/in. for a 30-coil spring of $\frac{1}{8}$-in.-square ceramic "wire" size. No precise spring rates have been determined above 1200 F, although experimental springs are operating up to 2000 F.

Typical Properties of Vitreous-bonded Alumina

Specific gravity	3.53-363
Tensile strength, psi	18,500-28,500
Compressive strength, psi	280,000-400,000
Modulus of rupture, psi	44,500-49,500
Izod impact, ft-lb/in	0.23-0.25
Hardness, moh	9+
Thermal conductivity Btu/hr/sq ft/°F per ft	0.02
Thermal expansion coefficient per °F x 10^{-6} (80-1300°F)	13.1-14.2
Softening temperature, °F	>3100
Thermal shock temperature, °F (for repeated air quench)	>1800
Volume resistivity (at 950 °F), ohm/cm³	7.5 x 10^{8}-1.3 x 10^{11}
Dielectric constant (at 10^{6} cycles)	8.95-9.25
Porosity, %	<1

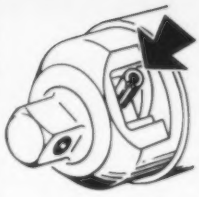
EDITOR'S NOTE: Other recent articles on materials for special spring applications:

"Spring Material for High-temperature Service," Aug '56, p 186, gives data on relaxation and creep for nickel alloys for service up to 700 F.

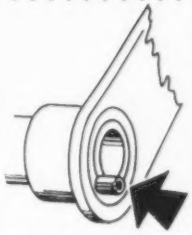
"Constant Modulus Alloy for Springs," July '56, p 135, includes mechanical properties and design stresses for a hardenable alloy with deflection rate unaffected by heat.

"Plastic Springs," June '56, p 183, describes method of manufacture for a glass-reinforced resin spring; gives torsional elastic properties and design stresses.

Rollpin® replaces 12 different fasteners

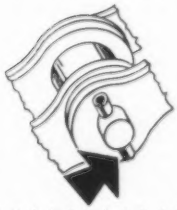


REPLACING A GROOVED PIN . . . in this application, Rollpin serves as a step pin in a ratchet wrench adaptor. With its light weight and high shear strength, Rollpin functions perfectly . . . cuts assembly costs.

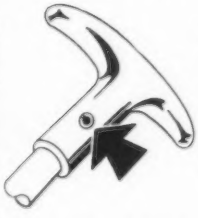


REPLACING A KEY . . . Rollpin demonstrates its ability to do away with precision tolerances, in this heating system damper arm. Faster, cheaper and more satisfactory than previous assemblies.

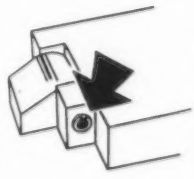
REPLACING A RIVET SHAFT . . . Rollpin serves as an axle for the sparkwheel of a cigarette lighter. No riveting or threading necessary . . . faster assembly. Note flush, clean fit.



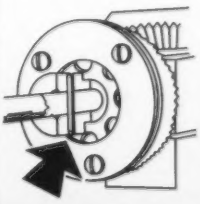
REPLACING A COTTER PIN . . . Rollpin assembly time is shorter, service life ten times longer. Vibration-proof flush fit. Easily removable.



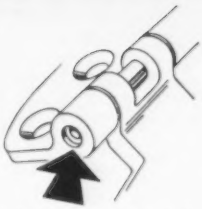
REPLACING A SET SCREW . . . to fasten automobile brake handle a short length Rollpin is self-retained in the hand grip but can easily be driven into over-drilled hole in shaft for simple handle removal.



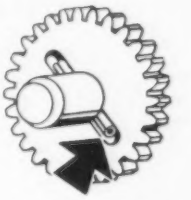
REPLACING A CLEVIS PIN . . . here Rollpin holds firmly in clevis, permits free action of moving member. Rollpin application shown is the plate of a home workshop tool.



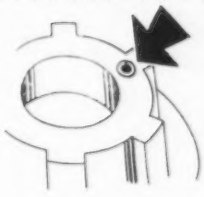
REPLACING TAPER PINS . . . in the assembly of precision differentials eliminated cost of taper pin reamers and the entire reaming operation. Rollpin costs less than a taper pin and installation is cheaper. They remove easily.



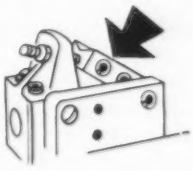
REPLACING A HEADED PIN . . . in this hinge pin application, Rollpin is simply and inexpensively driven in place, greatly reducing assembly costs. Constant spring tension holds Rollpin firmly in place . . . eliminates loosening of hinge due to wear.



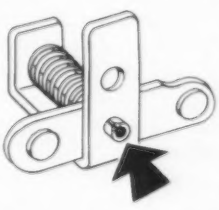
REPLACING A HUB ON A GEAR . . . Rollpin, self-retained in shaft, is simply snapped into molded slot to position sintered gear. This application, by an office equipment manufacturer, effects major savings in assembly. Rollpin's high shear strength is particularly valuable here.



REPLACING A DOWEL PIN . . . Rollpin is used here to prevent rotation of a thrust bearing. No reaming, no special locking. Easily removed. Lowest possible dowel pin cost.



REPLACING A BOLT AND NUT . . . Rollpins act as fasteners and pivots for the linkages in this electric welder. Rollpins may be used with a free fit in outer or inner members depending upon product design requirements.



REPLACING A RIVET . . . Rollpin serves as guide shaft for spring-loaded electrical interlock contacts. This electrical equipment manufacturer reports that rivet failure previously occurred at the clinched end under normal operating impact and vibration.

WHERE CAN YOU USE THIS SIMPLE FASTENER?

Rollpin is the slotted tubular steel pin with chamfered ends that is cutting production and maintenance costs in every class of industry.

Drives easily into standard holes, compressing as driven. Spring action locks it in place—regardless of impact loading, stress reversals or severe vibration. Rollpin is readily removable and can be re-used in the same hole. Made in carbon steel, stainless steel and beryllium copper. Write for samples and information, ELASTIC STOP NUT CORPORATION OF AMERICA, 2330 Vauxhall Road, Dept. R47-22, Union, New Jersey.

ROLLPIN TRADEMARK

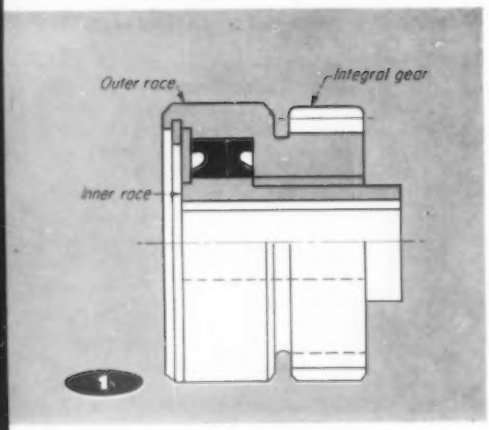
ELASTIC STOP NUT CORPORATION OF AMERICA

2330 VAUXHALL ROAD, UNION, NEW JERSEY

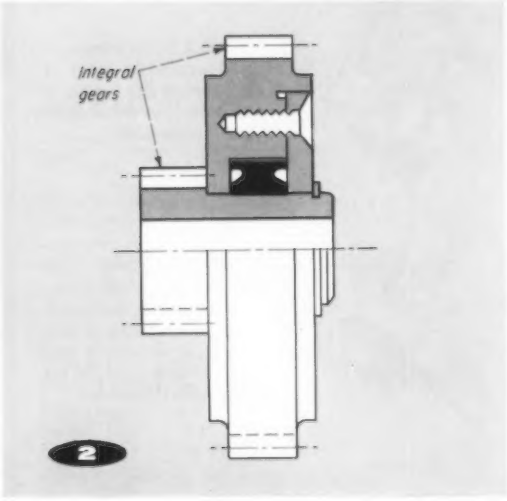
MULTI-FUNCTION OVERRUNNING

W. EDGAR MULHOLLAND
Executive Engineer and
JOHN L. KING, JR.
Project Engineer, Formsprag Co., Warren, Mich.

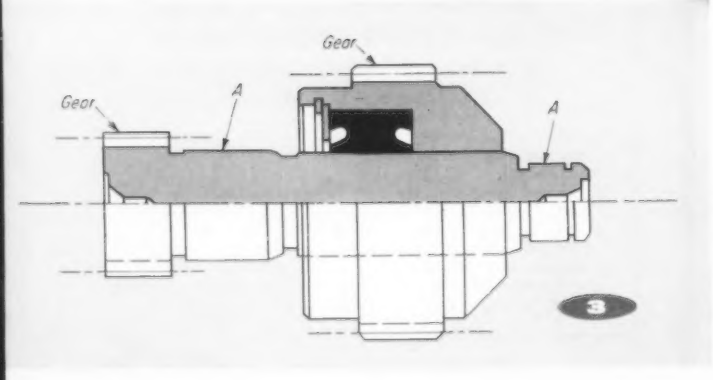
Clutch races that do more than one job reduce both space and costs. Here are seven examples of "full employment." Some basic applications of overrunning clutches were shown on page 118 of the November 25, 1957 issue.



Matched-strength race walls . . . have integral gear on outer race. This design gives: short length, concentricity between gear and clutch, space saving, less parts. Because the gear is integral, separate assembly is not necessary.

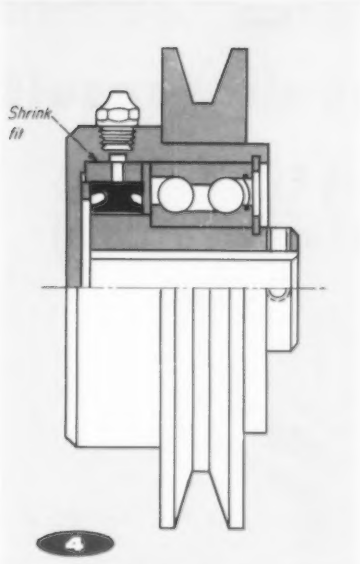


Integral gears on both races . . . provide extremely compact assembly. The inner race is bored by maker to special dimensions to suit whatever shaft it has to fit.

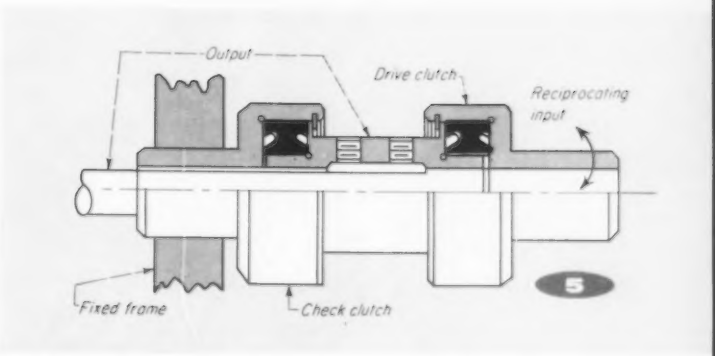


Inner race has integral gear . . . as well as mounting journals, for user's bearings, at points A-A. This arrangement eliminates necessity of separate mountings on user's shaft.

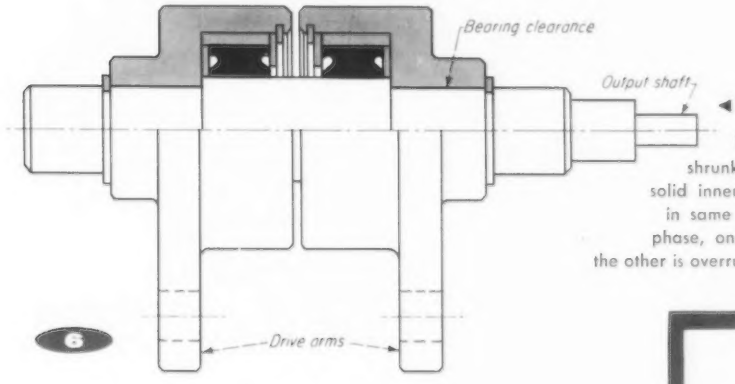
CLUTCHES



Dust-protected clutch . . .
has extended outer race shrunk into cast housing, which includes sheave. Both the bearings balls and the clutch mechanism are protected for operation in extremely dirty and exposed locations.

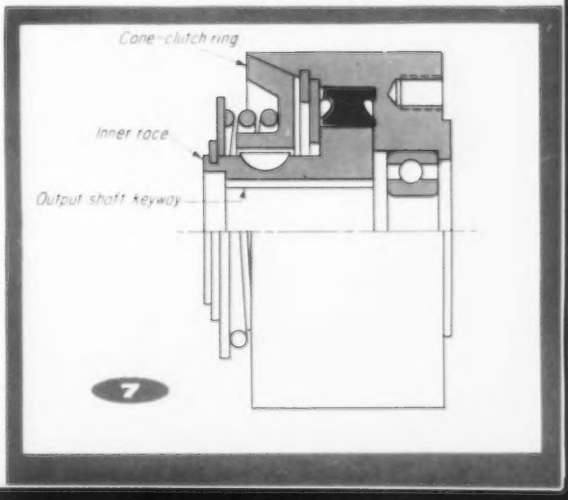


Combined clutches . . .
have common inner race. The two clutches act in opposite directions; after the indexing stroke of the first clutch has been completed, the second clutch operates as a backstop clutch. Arrangement provides compact assembly for feed-and-check clutch action; output shaft can extend from either end of assembly. Races are of matched strength.



Outer races as liners . . .
shrunk into cast lever arms and used with solid inner race. Both clutches drive and overrun in same direction, but because input is out of phase, one drive arm is transmitting power while the other is overrunning. This results in continuous output on shaft.

Cone clutch . . . ►
incorporated in outer race provides overload protection while overrunning clutch allows freewheeling in one direction without disengaging cone clutch. Cone-clutch ring is keyed to inner race; friction drive is between cone ring and outer race.



T-J spacemaker cylinder

Quality Engineered

to give quality results

with Extras . . . at No Extra Cost!

You get more—much more—when you specify and use any of T-J's complete line of Spacemaker cylinders. The Spacemaker is engineered to give you better, more accurate, and longer service—offers, exclusively, many extras . . . that are STANDARD, AT NO EXTRA COST!

Designed to eliminate tie-rods, providing greater strength . . . saves space . . . reduces manhours and costs in all push-pull-lift operations. OFF SHELF DELIVERY in a wide range of styles and capacities, with 64,000 combinations. Write for catalog SM 56-2 with complete engineering details. The Tomkins-Johnson Co., Jackson, Mich.

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RIVITORS · AIR AND HYDRAULIC CYLINDERS · CUTTERS · CLINCHORS

METAL PISTON ROD SCRAPER . . . Standard at No Extra Cost!

NEW "SUPER" CUSHION FOR AIR . . . Standard at No Extra Cost!

CHROME PLATED CYLINDER BORES AND PISTON RODS . . . Standard at No Extra Cost!

ONE PIECE PISTON . . . Standard at No Extra Cost!

NEW "SELF-ALIGNING" MASTER CUSHION FOR HYDRAULIC USE . . . Standard at No Extra Cost!

NO TIE-RODS TO STRETCH . . . Standard at No Extra Cost!

STREAMLINED DESIGN . . . Oil Pressure to 750 P.S.I.—air to 200 P.S.I. Standard at No Extra Cost!

FORGED SOLID STEEL HEADS . . . Standard at No Extra Cost!

HOW TO CALCULATE STRESS IN SHORT CYLINDRICAL SHELLS

LAWRENCE BERKO,

Design Supervisor, Walter Kidde & Co., Inc., N. J.

Here are formulas for deflection, shear force and bending moment caused by external forces such as flange-expansion and centrifugal force.

In long, thin-walled cylindrical shells, stresses and deformations near either end are not affected by conditions at the other end. Bending is local, and each end can be treated independently. Tabulated functions for the solution of shell problems are available in "Theory of Plates and Shells" by Timoshenko. However, for shells of relatively short length (shell parameter BL less than approximately five), both ends must be treated simultaneously. This results in lengthy and involved formulas. Solution-time is reduced by using the tabulated functions presented here for short cylinders.

These tables of shear, moment and deflection functions are for an open cylinder subjected to uniform radial pressure. One end of the cylinder is free while the other end is subjected to a specified radial deflection and zero change in rotation. The functions are given for BL increments of 0.10 up to $BL = 1.5$, and for somewhat larger increments up to $BL = 5.0$.

Some examples of designs where these tables are helpful are:

1 Flanged cylindrical shells subjected to uniform radial pressure or thermal effects. Generally, the flanges are very stiff against deflection and rotation, relative to the shell. However, because of possible combinations of pressure and temperature effects, the radially stiff flange would impose on the shell an easily calculable radial deflection. These formulas can then be used to evaluate stresses and free-end deflections.

2 Flanged cylinders subjected to equally spaced flange radial loads, with or without temperature and radial-pressure effects. Although max deflections caused by radial loads may be localized, a safe approximate solution to the problem for longitudinal stresses is obtained by assuming the deflection to be uniform.

3 A labyrinth sealing lip near the OD of a jet-engine turbine wheel. The turbine wheel expands radially because of centrifugal and thermal effects, but because of relative stiffness, the wheel restrains the supported end of the lip from changing its slope.

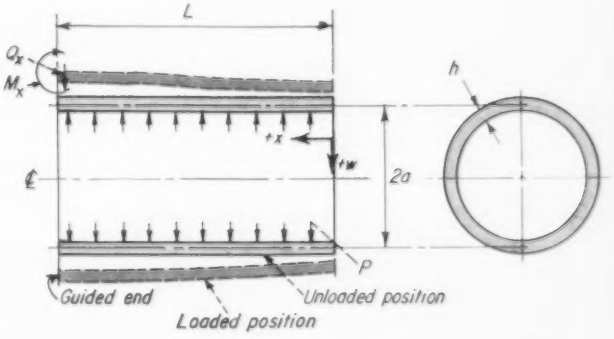
(Continued on page 83)

SYMBOLS

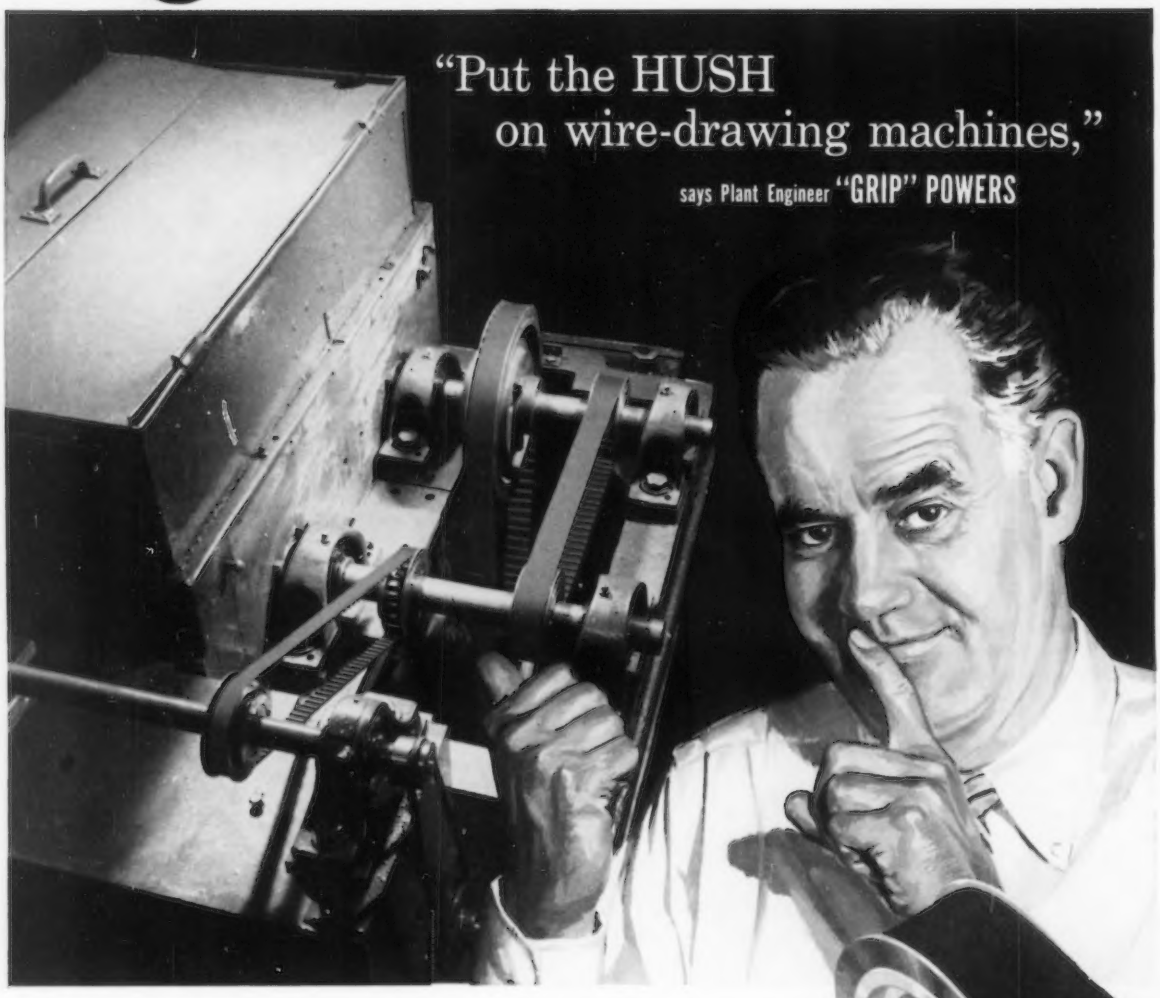
B = shell parameter, in.$^{-1}$
BL = nondimensional shell parameter
a = shell radius, in.
D = flexural rigidity, lb-in.
E = Young's modulus, psi
g = acceleration of gravity, in./sec^2
h = shell thickness, in.
L = shell length, in.
M_x = longitudinal bending moment per unit length of circumference, lb-in.
M = hoop bending moment per unit length of circumference, lb-in. $= \nu M x$
p = uniform pressure, psi
Q_x = radial shear force per unit length of circumference, lb
ν = Poisson's ratio
w = shell radial deflection, in.
x = shell coordinate along longitudinal axis, in.
δ = specified radial deflection at guided end, in.
ρ = material density, lb/in.^{3}
ω = angular velocity, rad/sec

F = deflection factor $= \dfrac{pa^2}{Eh}$

d = deflection function
m = moment function
s = shear function



PowerGrip "TIMING" BELTS



Wire-drawing machines in a large Indiana factory work 24 hours a day, 7 days a week ... drawing 1,650 feet of wire per minute. The chain drives on these machines caused a deafening noise.

A deafening noise, until a "U. S." power transmission engineer suggested a change-over to PowerGrip "Timing"® Belts. Comparative quiet now prevails: there is no more nerve-racking, unmerciful din. Workers now enjoy radio music throughout the plant. Moreover, cost savings resulted; the belts required no maintenance, whereas the metal belts required taking up twice a year and replacement once a year. The PowerGrip "Timing" Belts have been operating for well over a year, yet there's no sign of wear, no foreseeable need for replacement.

U.S. PowerGrip "Timing" Belts have an efficiency of close to 100%, because they have a positive, non-slip grip. They handle speeds up to 16,000 f.p.m., or so slow as to be imperceptible to the eye. These belts, plus on-the-spot engineering counsel from industrially-famed "U. S." power transmission experts are available at any of the 28 "U.S." District Sales Offices, or from selected distributors, or write us at Rockefeller Center, New York 20, N. Y. In Canada: Dominion Rubber Co., Ltd.

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HOW TO CALCULATE STRESS IN SHORT CYLINDRICAL SHELLS (concluded)

SAMPLE PROBLEM

For the rotating wheel with its integral short cylinder these factors are known or assumed:

$\delta = -0.010$ in.
$\omega = 500$ rad/sec
$\rho = 0.30$ lb/in.^{3}
$a = 10$ in.
$E = 30 \times 10^6$ psi
$g = 386$ in./sec^2
$L = 1.045$ in.
$h = 0.15$ in.

Then

$$B^4 = \frac{3(1-\nu^2)}{a^2h^2} = 1.21 \quad \text{for} \quad \nu = 0.3$$

or

$$B = 1.05$$

and

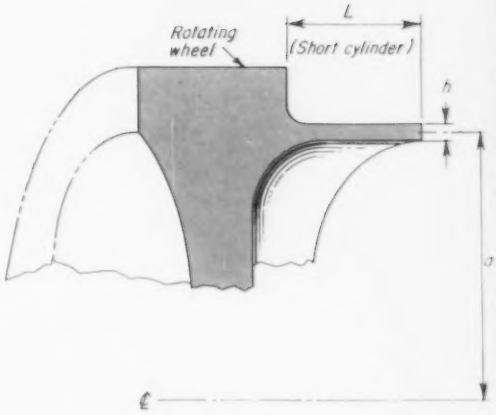
$$BL = 1.10$$

$$D = \frac{Eh^3}{12(1-\nu^2)} = 9280$$

$$p = \frac{\omega^2\rho ah}{g}$$

$$F = \frac{pa^2}{Eh} = \frac{\omega^2\rho a^3}{Eg} = \frac{(500)^2(0.30)(10)^3}{(30)(10^6)(386)} = 0.00648$$

For deflection, moment and shear solve by using tables to speed solution.



For deflection at free end

$$w_{x=0} = -F + (\delta + F)(d)$$
$$= -0.00648 + (-0.010 + 0.00648)(0.50630)$$
$$= -0.00648 - 0.00178 = -0.00826 \text{ in.}$$

For bending moment at guided end

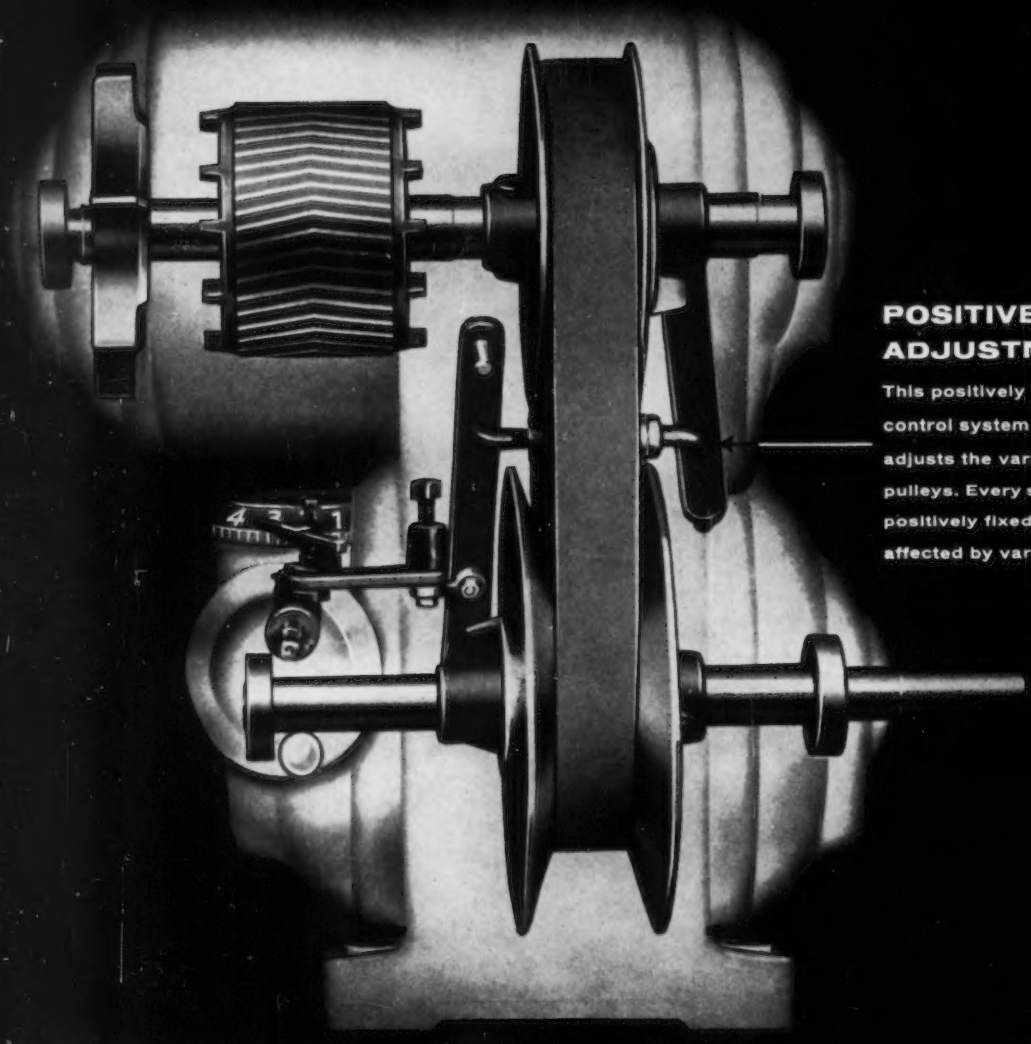
$$M_{x=L} = 2B^2D(\delta + F)(m)$$
$$= (2)(1.05)^2(9280)(-0.010 + 0.00648)(0.86236)$$
$$= -62 \text{ lb-in.}$$

For shear force at guided end

$$Q_{x=L} = 4B^3D(\delta + F)(s)$$
$$= (4)(1.05)^3(9280)(-0.010 + 0.00648)(0.88062)$$
$$= -131.5 \text{ lb}$$

BL	Deflection function, d $\frac{2 \cos BL \cosh BL}{\cos^2 BL + \cosh^2 BL}$	Moment deflection, m $\frac{\cosh^2 BL - \cos^2 BL}{\cosh^2 BL + \cos^2 BL}$	Shear function, s $\frac{\sin BL \cos BL + \sinh BL \cosh BL}{\cos^2 BL + \cosh^2 BL}$
0	1.0	0	0
0.1	0.99995	0.01000	0.09999
0.2	0.99920	0.03995	0.19993
0.3	0.99596	0.08978	0.29952
0.4	0.98731	0.15884	0.39797
0.5	0.96937	0.24560	0.49388
0.6	0.93786	0.34702	0.58506
0.7	0.88874	0.45842	0.66878
0.8	0.81948	0.57311	0.74207
0.9	0.73013	0.68331	0.80242
1.0	0.62382	0.78157	0.84851
1.1	0.50630	0.86236	0.88062
1.2	0.38486	0.92298	0.90060
1.3	0.26660	0.96318	0.91130
1.4	0.15708	0.98758	0.91584
1.5	0.06005	0.99819	0.91706
1.75	−0.11982	0.99279	0.91810
2.0	−0.21854	0.97583	0.92596
2.5	−0.25689	0.96644	0.95752
3.0	−0.19478	0.98085	0.98416
3.5	−0.11265	0.99363	0.99619
4.0	−0.04784	0.99885	0.99938
4.5	−0.00937	0.99996	0.99983
5.0	+0.00764	0.99997	0.99985

Precalculated coefficients . . . for deflection at the free end; shear force and bending moment at the guided end. These factors generally govern design. Numerical solutions of the function formulas are substituted in the main formulas, speeding up their solution. Intermediate values of *BL* may be extrapolated.



POSITIVE PULLEY ADJUSTMENT

This positively linked speed control system reciprocally adjusts the variable pitch pulleys. Every speed setting is positively fixed and is not affected by variations in load.

New Worthington motor drive gives you

ACCURATE SPEED REGARDLESS OF LOAD

Once you set the speed on a Worthington variable speed motor drive, the pulley holds it – maintaining accurate speed control regardless of variations in load.

This unique feature is the result of "positive pulley adjustment." A positively-linked speed control system reciprocally adjusts the variable pitch pulleys. Unlike spring-equipped drives which constantly maintain maximum belt tension to meet occasional peak loads, belt tensions in a Worthington drive never exceed the actual load transmitted. Peak and momentary starting loads are transmitted just as smoothly as they would be with a standard fixed speed V-belt drive.

Positive pulley adjustment also results in a compact design with inherently long belt life. The wide-angle design of the belt offers deep side walls for greater contact area. This feature gives you high power capacity with minimum belt pressure. The large diameter pulleys assure smooth, efficient operation with little wear.

The new line is available in speed variations up to 10:1 and horsepower ratings from ½ to 25 hp. You can specify finger tip speed control or one of the many types of remote controls – both automatic and mechanical. For complete information, write for Bulletin 1610-B1. Address Section MV-78, Worthington Corporation, Oil City, Pa.

WORTHINGTON

Digital Counter Has Straight-line Readout

In this decade counter, numbers are presented as 2½-in.-high numerals on a flat plane and in correct straight-line reading sequence. Numerals are formed by 40 high-intensity neon bulbs, so that failure of two or three does not affect recognition. This provides "fail-safe" operation, the manufacturer states.

The memory circuit governing the readout element changes only on command in normal operation; a pushbutton switch converts the unit to continuous counting. Modular plug-in construction allows relay trees and lamp assemblies to be used separately or with other equipment. Two or more readouts can be actuated by one digital counter. Price, about $770; delivery beginning in March. **Computer-Measurements Corp., 5528 Vineland Ave., North Hollywood, Calif.**

Circle 1, inside back cover

Diaphragm Pump Delivers Oil-free Air

A low-volume, diaphragm pump that was originally developed for hospital applications delivers oil-free air. The 16.7-lb pump is designed for continuous operation, and offers vacuum up to 22 in. hg, pressure up to 40 psi, and a max displacement of one cfm at free flow. A Form "G" G.E. motor is used and electrical requirements are 115 v, 60 cps. However, 220-v, 60 or 50 cps motors are also available. Valve gasket and diaphragm are neoprene-nylon. Approximate price, $90—quantities over 200, about $50; delivery of 100-200 units, 30 days. **Air-Shields, Inc., Hatboro, Penna.**

Circle 2, inside back cover

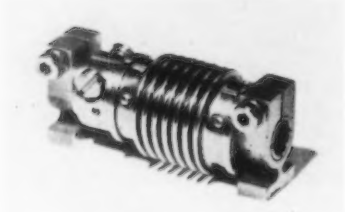
CONTINUED ON PAGE 86

Liquid level control . . .

system is based on an air line, or bubbler, placed below the surface of the liquid. Air at 15 psi or less passes through the line, causing a slight bubbling action.

When liquid drops slightly below proper level, there is less pressure on bubbler tip. Less pressure is then required to force air out of pipe. This change in pressure is transmitted back to a static pressure regulator, which repositions control valve on the liquid-supply line. The liquid level can be adjusted over a range of 1½ in. List price, $104. Most models available from stock. **Powers Regulator Co., 3434 Oakton St., Skokie, Ill.**

Circle 3, inside back cover



Coupling for zero adjustment . . .

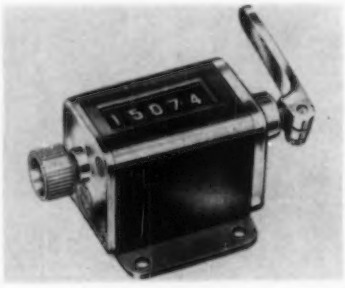
is made entirely of stainless steel. Range of adaptability is for four basic shaft sizes: ⅛ to ⅛, 7/32 to 7/32, ¼ to ¼ and 0.1200 to ⅛ in. Can be applied on pin and clamp-type hubs. Design allows adjustment on sensitive shafts of servo motors, resolvers and synchros. Available from stock. **PIC Design Corp., 477 Atlantic Ave., E. Rockaway, N. Y.**

Circle 4, inside back cover

DC rotary torque solenoids . . .

incorporate a double-cam action that provides outputs to duplicate any torque requirements. Special combination thrust and radial bearings reduce axial shaft movement to ±0.0005 in. Any rotary stroke from 5 to 180°, clockwise or counter clockwise, can be provided. Case, armature and core are made of hydrogen-annealed ingot iron, a magnetic material. Power range is from 7 to 350 w. Withstands shock to 50 g at 20 cps. Weighs 1 oz to 5 lb. **Powerdex Co., 2501 E. 68th St., Long Beach, Calif.**

Circle 5, inside back cover



Small reset counter . . .

for speeds to 1000 rpm, 1000 strokes per min, has a capacity of 9999 or 99999. Figures are 0.175 in. high, white on a black ground, and return to zero after max count has been reached. Dimensions are 8½ x 1 7/16 x 2⅜ in. for the five-figure and slightly smaller for the four-figure counter. Base flanges have mounting holes. All shafts are stainless steel; components are nylon. Drive shaft input bearing is nylon, which requires no lubrication. Drive levers can be ⅞ or 1 7/16 in., from stock. Drive may be arranged from either right or left-hand end of the case with the reset knob opposite. Counters register in one direction, regardless of driveshaft input direction. May be obtained to add or subtract, not both. **Technicraft, 6222 Ridge Ave., Philadelphia 28.**

Circle 6, inside back cover

Motor-speed control package . . .

includes an ac motor, allowing use of normal three-phase, 60-cps current without rectification. Furnished in ⅛, ¼, ⅓ and ½-hp sizes for operation on 220 v. Motors are mounted on NEMA size-56 frames and can be interchanged. In addition to the motor and frame, the package has a built-in tachometer to sense motor speed and a magnetic amplifier speed controller. Speed set by the control potentiometer is reached without hunting. Unit is essentially a constant-torque motor drive, with power output directly proportional to motor speed. Other features are dc plugging for time-controlled braking; controlled acceleration; pushbutton for start-stop; overload protection. **Fidelity Instrument Corp., 1000 E. Boundary Ave., York, Penna.**

Circle 7, inside back cover

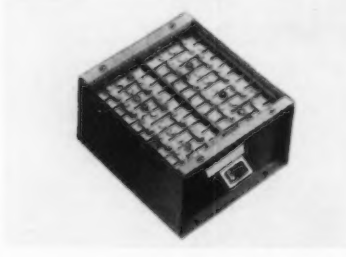
Bypass valve . . .

regulates liquid pressure as supplied by pressure pumps. Valve is set to open at the required pressure; when system demand is reduced, the excess liquid is bypassed to supply. Models are available with fixed setting for relief-to-atmosphere applications. In two sizes, ¾ and 1 in., for pressures from 10 to 250 psi. The high-capacity, automatic bypass valve is all bronze. **Watts Regulator Co., Lawrence, Mass.**

Circle 8, inside back cover

Rechargeable batteries . . .

are general-purpose, sealed, nickel-cadmium units with nominal voltages in multiples of 1.2 v with rated capacities of 0.1 to 160 amp-hr. Patented sintered plates used in the series make possible



CONTINUED ON PAGE 88

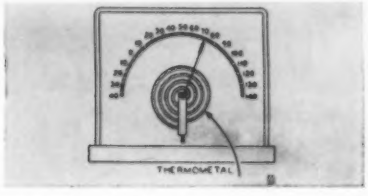
No. 1
of a series of ads dealing with basic facts about thermostatic metals.

Designing for Product Improvement With WILCO THERMOMETAL®

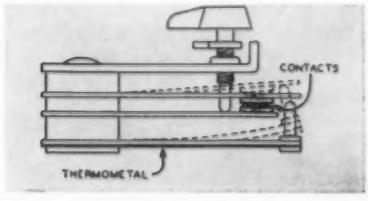
Thermometal (thermostatic metals) are laminations of two or more different metals with unequal coefficients of expansion. The difference in rate of expansion causes them to change shape with changes in temperature and, if restrained, to build up force.

This basic fact is of great industrial importance, for it makes possible the application of Thermometal in indicating and controls devices in 4 broad categories.

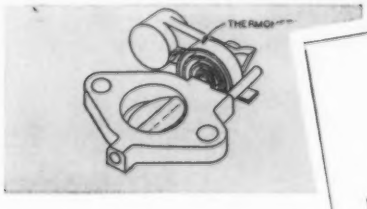
1. Temperature Indication, as in Thermometal thermometers.



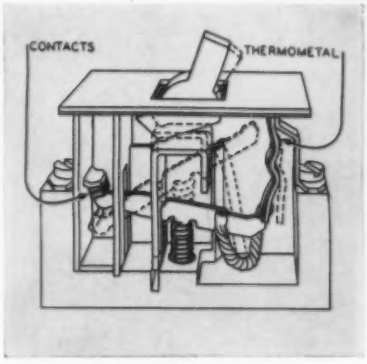
2. Temperature Control, as in electric Irons, toasters, or room thermostats.



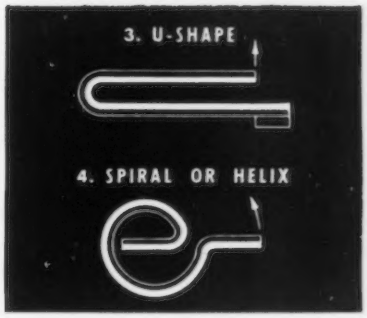
3. Temperature Compensation, as in automotive heat manifold control.



4. Sequence Control by Functional Heating, as in electric circuit breakers for overload protection.



Thermometal can be rolled to any desired thickness and formed into almost any shape, and still respond to temperature changes. For this reason it is a unique thermal element, which functions without linkages, seals, special mountings, and in most applications without electrical energy. Thermometal can be made to perform simple flexing motion, rapid snap action, and rotary or twisting motions. Four basic shapes are used alone or in combinations to obtain these motions:



According to the application, the selection of Thermometal is generally governed by four performance factors:

1. Maximum temperature encountered in service: (300°F, 500°F, 800°F, or 1000°F)
2. Temperature range over which maximum sensitivity is required: 50°–300°F (low); 150°–450°F (medium); 300°–600°F (high); 500°–800°F (extra high)
3. Deflection and force required
4. Electrical conductivity

The H. A. Wilson Company is the American pioneer in the development and manufacture of thermostatic metals. We produce over 40 metals for this use. Also we make a complete line of electrical contacts for use with Thermometal.

Reprints of this series are available on request. For further information about our products, ask for the Wilco Blue Book, most complete reference ritten on Thermometal.

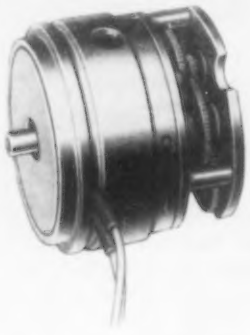
THE H. A. WILSON COMPANY
WILL HENCEFORTH BE DESIGNATED AS
ENGELHARD INDUSTRIES, INC.
H. A. WILSON DIVISION
2655 U.S. ROUTE 22
UNION, NEW JERSEY

WILCO®
THERA
ELECTR
CONTA
COMPO
SPECIAL
ALLOYS

vidence
...HARD INDUSTRIES

construction of cells with low internal resistance, capable of delivering peak currents to 20 times normal rated capacity. Operates within the range of —20 to 165 F, with special units available to —40 F. Can be stored without deterioration and can be recharged using constant potential or constant current systems. Applications include engine starting, emergency lighting, communications, instrumentation, portable equipment, marine and railroad uses. **Alkaline Battery Div., Gulton Industries, Inc., 212 Durham Ave., Metuchen, N. J.**

Circle 9, inside back cover



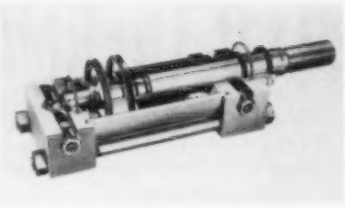
Servo motor gearhead . . .

is a multispeed, single package unit. Changes ratios internally when dc voltage is applied to, or removed from, an actuating solenoid. Ratios of the size-14 unit shown are on the order of 1800:1 de-energized, and 36,000:1 energized. Similar two-speed units are available in all ratios or combinations of ratios. Furnished with housings to mount on servo motors. The gearhead, designed for integration with sizes 11, 14 or 18 motors, requires 0.008 in-oz of starting torque and will operate 12 in-oz of load torque. Operates in ambient temperatures of —40 to 257 F. Primary applications are in positioning mechanisms that require fast approaches, but slower zeroing or synchronizing action. **Bowmar Instrument Corp., 8003 Bluffton Rd., Ft. Wayne, Ind.**

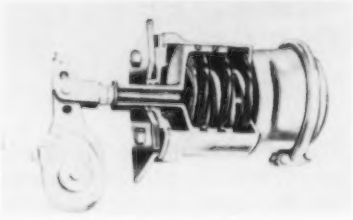
Circle 10, inside back cover

Air and hydraulic cylinders . . .

for heavy-duty service are rated at 1000 psi hydraulic, 200 psi air, and for non-shock load to 1500 psi hydraulic. Nine bore sizes ranging from 1½ to 8 in. are available in 11 standard mountings. Cylinders are heat-treated, stress-relieved, 100,000-psi-min-yield-strength steel and have been ground, hardened, hard-chrome-plated and polished. Removable cartridge-type bearing provides accurate seats for rod seal, rod wiper and static outer seal. Barrel seals use pressure-sensitive rubber O-rings. **Hydro-Line Mfg. Co., 5600 Pike Rd., Rockford, Ill.**



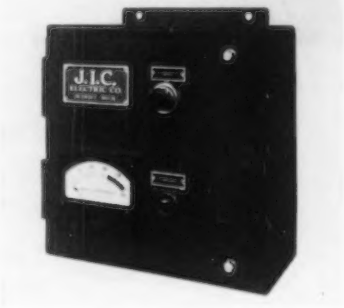
Circle 11, inside back cover



Air brake attachment . . .

is added to the existing service brake system and provides an automatic application of the service brakes when the air supply is depleted. Driver control of brake attachments can be provided by locating a hand valve in cab. If air pressure drops below 60 psi, attachments automatically begin to brake vehicle. Installed between the service brake chamber and its mounting bracket. **Maxi Corp., P.O. Terminal Box 3129, Los Angeles 54.**

Circle 12, inside back cover



Standard load switch . . .

controls overload conditions of both fractional and multiple-horsepower electric motors. A single unit handling all horsepower ranges can be installed in any electrical circuit and adjusted so that any predetermined overload will operate through the load switch to activate visual or audio signals, to open and close contacts, to stop motor, stop feed, reverse feed. Operates on 110-v, 60-cps current and uses no vacuum tubes or complex electronic devices. Requires two simple adjustments to set up and fits in a standard cabinet 12 x 14 x 6 in. Manufactured in four standard models. **J.I.C. Electric Co., 19255 W. Davison, Detroit 23.**

Circle 13, inside back cover

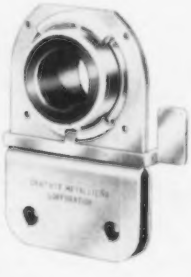
Explosionproof variable transformers . . .

in three models are available in cast aluminum housings and are designed for panel mounting. Model 6240 has a power input of 120 w, 60 cps and output of 0 to 140 v, 7.5 amp, 1.0 kva max. Medium-size model 7001 has an output of 0 to 135 v, 3 amp; small-size model 7009 has an output of 0 to 132 v, 1/25 amp. Weight is from 29 lb for the largest to 8½ lb for the smallest unit. Largest is 9⅜ in. deep. **I-L-S Instrument Corp., 4550 W. 160th St., Cleveland 11.**

Circle 14, inside back cover

Hanger bearing assemblies . . .

originally designed for conveyor rolls have bushings made of a composition that is a dry lubricant in itself, able to retain its properties from —450 to 750 F. These assemblies are applicable to high-temperature equipment and to applications in



CONTINUED ON PAGE 90

TWO GREAT BEARING DEVELOPMENTS ROLLED INTO ONE!

PLYA-SEAL WIDE INNER RING BALL BEARING

Designed expressly for slow speed applications and wet or dirty operating conditions

New Fafnir Plya-Seal Wide Inner Ring Ball Bearings are a combination of two outstanding bearing developments. The most effective seal ever devised for retention of grease and protection against contamination, plus the famous Fafnir self-locking collar, for cost-cutting, twist-of-the-wrist bearing installation. This combination of features offers you several advantages . . .

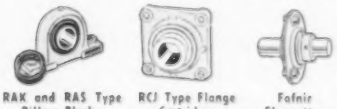
Best protection yet against dirt, dust, steam, water, lint, other contaminants on slow to moderate speed applications. Contact-type, Plya-Seals seal out abrasive or corrosive material, seal in factory prepacked lubricant.

Less Maintenance — In many applications, non-relubricatable bearings may be used. They require virtually no maintenance time or expense. In other applications, where bearings receive hard or constant use, relubricatable types are available. They require only occasional greasing, even under severe conditions.

Longer Service life — Plya-Seals protect against premature bearing wear or failure. Contaminants cannot damage balls or races; sealed-in lubricant ensures against bearing "running dry".

Simplified Designing — Bearing housings may be designed without incorporating separate housing seals. Plya-Seals provide full protection; make possible simplified, less costly, more compact housings.

Power Transmission Units incorporating new Fafnir Plya-Seal Wide Inner Ring Bearing

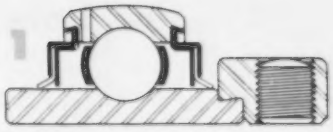


RAK and RAS Type Pillow Blocks | RCJ Type Flange Cartridges | Fafnir Flangettes

Write for bulletin containing complete specifications on Fafnir Plya-Seal Wide Inner Ring Ball Bearings and Power Transmission Units. The Fafnir Bearing Company, New Britain, Conn.

FAFNIR
BALL BEARINGS
MOST COMPLETE LINE IN AMERICA

1



PLYA-SEALS

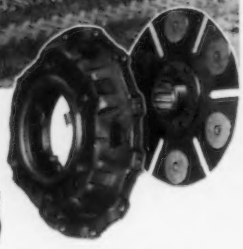
As incorporated in the Fafnir Plya-Seal Wide Inner Ring Ball Bearing, the Fafnir Plya-Seal consists of a synthetic rubber-impregnated fabric sealing washer sandwiched between dished steel plates. Seal flares out, maintaining constant contact with ground outside diameter of inner ring. Years of service have proven Plya-Seals the most effective seal ever developed for ball bearings.

2

SELF-LOCKING COLLAR

Originated by Fafnir, this famous development has cut costs and simplified assembly throughout industry. Bearings slip onto shaft; are locked securely with simple twist of self-locking collar. No need for lock nuts, shoulders, sleeves, washers, or adapters. Positive binding action increases with use.

ROCKFORD



MORLIFE® CLUTCHES

Keep Heavy-Duty Machines 400% More Hours ON the Job 90% Less Time IN the Shop

Reports from a wide range of users state that MORLIFE clutches serve from four to ten times longer than previous types of friction clutches using organic facing materials. *Adjustments and plate replacements have been reduced to one-tenth those required by previous clutches.* The longer on-the-job hours and increased pay loads which MORLIFE clutches make possible furnish a competitive advantage for machines in which these NEW clutches are used. Increased clutch life results in decreased operation cost of vehicles or equipment. Let our engineers show you how *your* product will benefit through using MORLIFE clutches.

Small Spring Loaded

Automotive Spring Loaded

Heavy Duty Spring Loaded

Oil or Dry Multiple Disc

Heavy Duty Over Center

Light Over Center

Power Take-Offs

Speed Reducers

SEND FOR THIS HANDY BULLETIN

Shows typical installations of ROCKFORD CLUTCHES and POWER TAKE-OFFS. Contains diagrams of unique applications. Furnishes capacity tables, dimensions and complete specifications.

ROCKFORD Clutch Division BORG-WARNER

209 Catherine St., Rockford, Ill., U.S.A.

Export Sales Borg-Warner International — 36 So. Wabash, Chicago 3, Ill.

ROCKFORD B-W BORG-WARNER

CLUTCHES

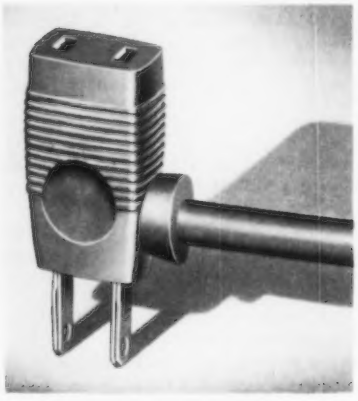
sub-zero temperatures. Offered for various mounting arrangements. All models have a quick-release feature to permit reversing bushing. **Graphite Metallizing Corp., Yonkers, N. Y.**

Circle 15, inside back cover

Electrical selector switch . . .

has self-wiping contacts. Switch has been developed for electrical installations requiring heavy-duty controls. Provides motion that is either to or from the user; no buttons to push or dials to turn. Models available in four to ten contacts as standard equipment. **Sel-Set Machinery Corp., 290 Moyer Lane, Salem, Ore.**

Circle 16, inside back cover



Series attachment plug . . .

for remote switching or control of appliances, lighting or electronic instruments is molded onto the cordset of the controlling or switching device. Unit is plugged directly into any power outlet and the controlled unit is plugged into the outlet on the end of the series attachment cap. Used with two-conductor cable, any simple switching device controls the power to this outlet. For control devices

(Continued on page 94)

AlSiMag® ALUMINA CERAMICS

EXCEL IN MECHANICAL APPLICATIONS!

Great Wear Resistance • Dimensional Accuracy • High Strength • Outstanding Performance at High Temperatures

AlSiMag Alumina parts have exceptional tensile, compressive and flexural strengths . . . superior resistance to impact and thermal shock. A rare and important extra . . . these "super ceramics" maintain their excellent physical and electrical properties in ambient temperatures in the 1000° F. range with relatively little "tapering off!" Several AlSiMag Alumina compositions are safe for operation at continuous temperatures well above 2500° F.

Smooth, uniform surfaces. Precision tolerances. Flatnesses within light bands are possible on many parts; so are faces parallel within .0005". Complete production facilities for speedy shipment in any quantity. Prototypes for test if you wish.

The industry's widest choice of special-purpose ceramic materials. Send blueprint or sketch with details of operation for complete data on the AlSiMag Alumina best suited for your purpose.

RATE HIGH AS: Bearings • Communication Parts • Compass and Gyroscope Parts • Cylinders • High Temperature Metalized Seals • Heliarc Welding Tips • High Speed Motor Parts • Instrument Parts • Jet Engine Parts • Machine Parts • Measurement Devices • Missile Parts • Pistons • Pump Liners, Seals and Plungers • Radomes • Rollers • Rotary Seals • Welding Jigs

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AMERICAN LAVA CORPORATION

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56TH YEAR OF CERAMIC LEADERSHIP

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OHMITE® RITEOHM®

New Metal Film

Write for Bulletin 155A

A new kind of precision resistor with these important features:

Full ¼-watt Rating at 150°C Ambient These new units may be used at *full rated wattage* in higher ambients than other types of precision film resistors. Rated at ½ watt at 125°C.

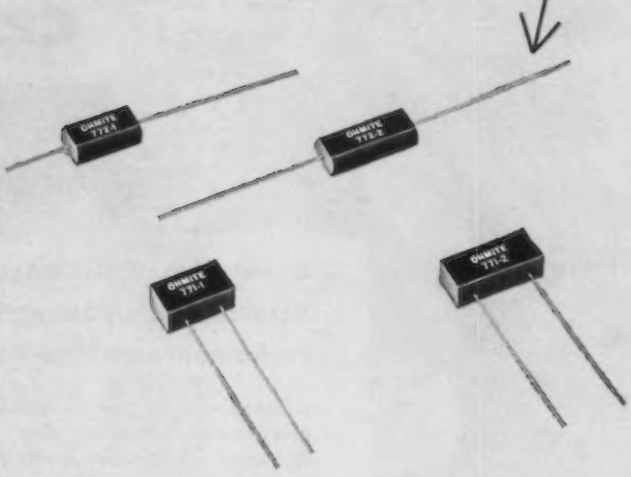
Excellent High-Frequency Characteristics Ohmite Metal Film units can be used in high-frequency and pulse circuitry for which wire-wound precision resistors are unsuitable.

Low Temperature Coefficient of Resistance Standard temperature coefficient is 0 ±30 ppm/°C (0 ±.003%/°C) over a wide range of -55°C to +190°C (25°C reference ambient) regardless of resistance value.

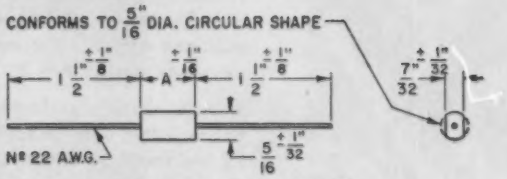
Long Term Load and Shelf Stability A temperature of +150°C is used in Ohmite load life and temperature cycling tests, which is considerably above MIL requirements.

Resistance Range Two sizes provide over-all range of 100 ohms to 300K ohms. The smaller unit provides resistances from 100 ohms to 150K ohms; larger unit covers the range from 150K to 300K ohms.

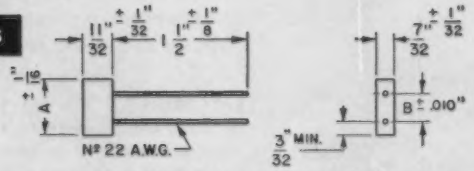
Ohmite Metal Film Resistors constitute a major advance in precision resistor technology and represent a radical departure in construction from wire-wound precision resistors. They employ no wire for the resistance element, yet feature excellent stability and noise level comparable to wire-wound units. Thus they are ideal for high-gain electronic circuits.



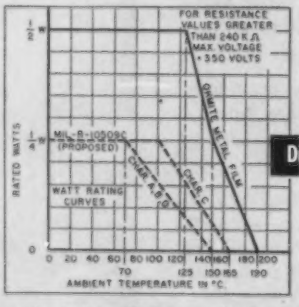
RITEOHM SERIES 77



AXIAL LEAD TYPE	DIM. "A"
772-1	5/8"
772-2	13/16"



RADIAL LEAD TYPE	DIM. "A"	DIM. "B"
771-1	5/8"	.300
771-2	13/16"	.500


FOR RESISTANCE VALUES GREATER THAN 240 K Ω MAX VOLTAGE = 350 VOLTS
MIL-R-10509C (PROPOSED)
OHMITE METAL FILM
WATT RATING CURVES
CHAR. A & B
CHAR. C
RATED WATTS
1/2 W
1/4 W
0
0 20 40 60 80 100 120 140 160 180 200
70 125 150 155 190
AMBIENT TEMPERATURE IN °C.

Watt rating chart for all types. At lower ambients, units may be uprated within voltage limitations.

Dimensions and Styles

Construction and Principle of Operation

The resistance element of Ohmite Metal Film Resistors consists of a thin film of special metal alloy permanently bonded onto a high-quality glass substrate. Terminal leads are securely fixed to the resistance element for positive, trouble-free connections. The entire assembly is hermetically sealed in a special moisture-resistant, high-temperature, plastic case with a special high-temperature Ohmite resin. Terminal leads may be axial or radial as shown.

PRECISION RESISTORS

Wire-Wound

Write for Bulletins 145 and 154

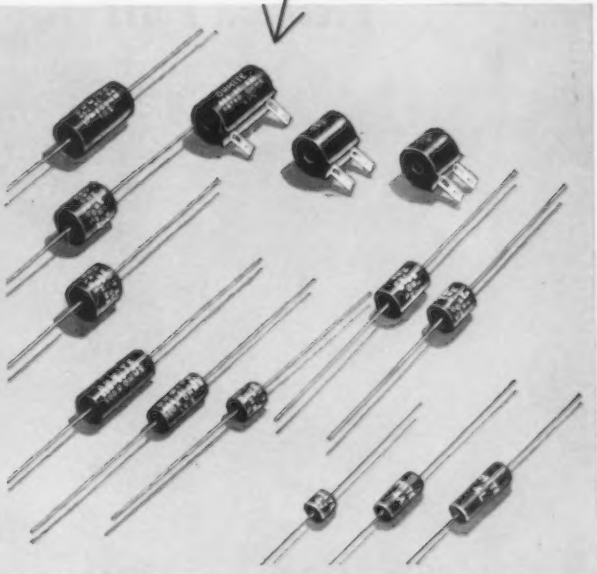
COMPLETELY ENCAPSULATED TYPES
series 85 and 86: Exceed MIL-R-93A, Amendment 2, at 125°C ambient

Ohmite Riteohm® Resistors have the resistance wire welded to the terminals by a patented Ohmite process. The resistance wire is fused to the terminal lug, giving a perfect and permanently stable electrical connection. This is extremely important in eliminating noise in audio circuits or instability in other highly sensitive circuits.

The encapsulating resin, which encloses *all* parts, is specially Ohmite-compounded. Its coefficient of expansion closely matches that of the bobbin, wire, and terminals—preventing internal movement and possible damage to the resistance wire. In addition, terminals remain firmly sealed in the resin, preventing the entrance of moisture into the windings.

Series 85, axial lead type, features tolerances to ±0.1%. Resistance to 3.0 megohms. Many stock sizes available.

Series 86, radial lug terminals, features tolerances to ±0.1%. Resistance to 2.2 megohms. Many stock sizes available.

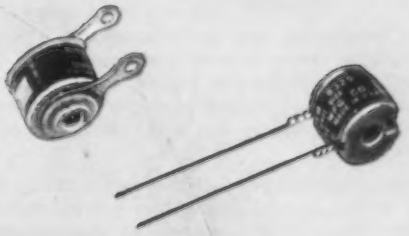


Varnish impregnated types

Series 83, precision Riteohm® resistors, feature specially enameled, alloy-resistance wire which is pie-wound on ceramic bobbins. Resistance to 2.6 megohms; radial wire leads. Units are vacuum-impregnated with a special varnish for protection against humidity.

Series 84, precision resistors, like Series 83, are vacuum-impregnated with a special varnish for optimum protection against humidity. Resistance to 4.8 megohms; radial terminal lugs.

Other types of terminations also available.



Vitreous-enameled types

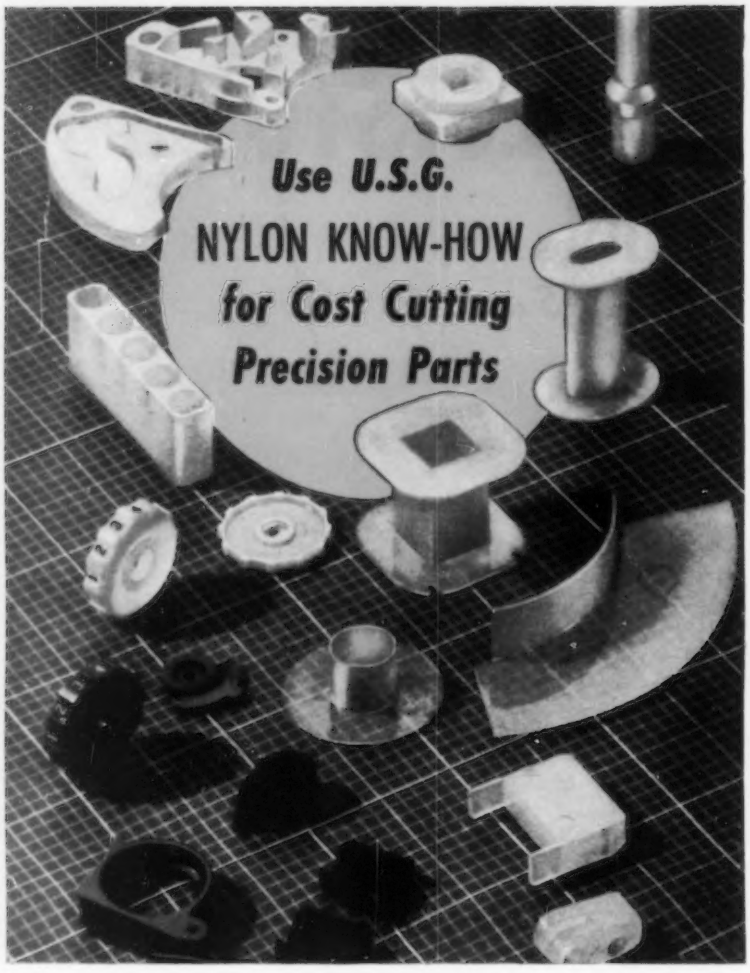
Ohmite vitreous-enameled resistors are space-wound in a single layer on a ceramic tube. Any of these resistors can be furnished to precision tolerances in sizes from 3 watts to 200 watts, in various terminal types, and in a wide range of resistance values.

BE RIGHT WITH

OHMITE® QUALITY Components

RHEOSTATS RESISTORS RELAYS
TAP SWITCHES TANTALUM CAPACITORS
R. F. CHOKES VARIABLE TRANSFORMERS

OHMITE MANUFACTURING COMPANY
3611 Howard Street, Skokie, Illinois



For those mechanical and electro-mechanical parts that must be strong, durable, wear resistant, *design to use Chemiseal Nylon* (du Pont ZYTEL). It has the highest compressive strength, is the most rigid, has the best resistance to heat, abrasion, chemicals, solvents, oils and greases—and is the lowest priced of the standard nylon compositions.

U.S.G. Nylon service goes all the way, offering STOCK (sheets, tape, rod, tubing, special shapes), for manufacture of parts in your own plant; MACHINING (precision fabrication on high speed automatics) to your specifications; and INJECTION MOLDING (volume production to close tolerances at lowest cost).

To be sure you are securing your parts at the lowest cost, consistent with your requirement at every stage from prototype to plant scale production—*check your costs with U.S.G. "know-how"*.

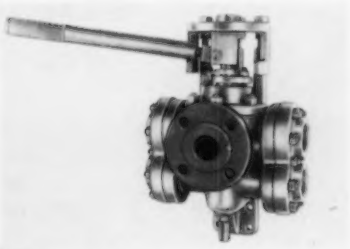
For prompt service, contact one of The Garlock Packing Company's 30 sales offices and warehouses throughout the U.S. and Canada, or write

United States Gasket Company
Camden 1, New Jersey

United States Gasket *Plastics Division of* **GARLOCK**

requiring power, three-conductor cables are used. Series plug is molded of matching plastic on vinyl-insulated wire of any color, type and size. **Miller Electric Co., Pawtucket, R. I.**

Circle 17, inside back cover



Transfer valve . . .

for duplexing two strainers, heat exchangers or other equipment where fast and smooth transfer of flow from one unit to another is required has six ports, including a common inlet and outlet. Flow is through the single inlet, to either of two pieces of equipment, and out of common discharge connection. Design provides transition of flow from one unit to the other on a proportional basis. A single operating handle jacks up the plug before rotation. It cannot be rotated until it is clear of the seat and an indicator shows position of the plug at all times. Available in 1-in., 600-lb flanged and 1½ in. 150-lb flanged sizes. **A. W. Cash Co., P.O. Box 551, Decatur, Ill.**

Circle 18, inside back cover

Miniature clinch nuts . . .

are self locking. Integral metal cap design was developed for use inside a miniature transformer. In potting operations, it prevents compound from flowing inside the nut threads; in other applications, the cap protects closely packed delicate wiring and components from bolt end damage. Mounted by expanding the short knurled shank in the installation hole. It then becomes a fixed fastener, suited for restricted spaces that will not permit normal

(Continued on page 99)

FLASH...
an *Original Idea!

You Can Count On... to Pay Off!

Series 1205
Reset Magnetic Counter

It's the **Original Equipment* idea . . . which simply means that, when you're figuring on electrical or mechanical counters in any new product, it pays to *design them in, when you begin.*

For then Veeder-Root quite likely can save you time and money by adapting or modifying a *standard* counter to your needs, instead of a special which you might specify on your own. This solves the counter problem . . . and saves you time in engineering, purchasing and assembly.

What's more, you give your product new sales-advantages: Direct-reading digits, instead of hard-to-read dials and verniers . . . instant remote indication if needed . . . up-to-the-minute performance records that serve as a basis for production-*Count*rol, and as proof of your performance guarantee. So don't let counters take a back seat in your new-product plans. *Design them in, when you begin* . . . it pays in many ways. Do you have the newest Veeder-Root Catalog? Write

Everyone Can Count on Veeder-Root
INCORPORATED

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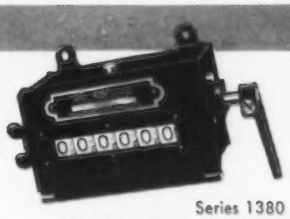
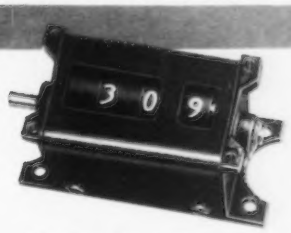


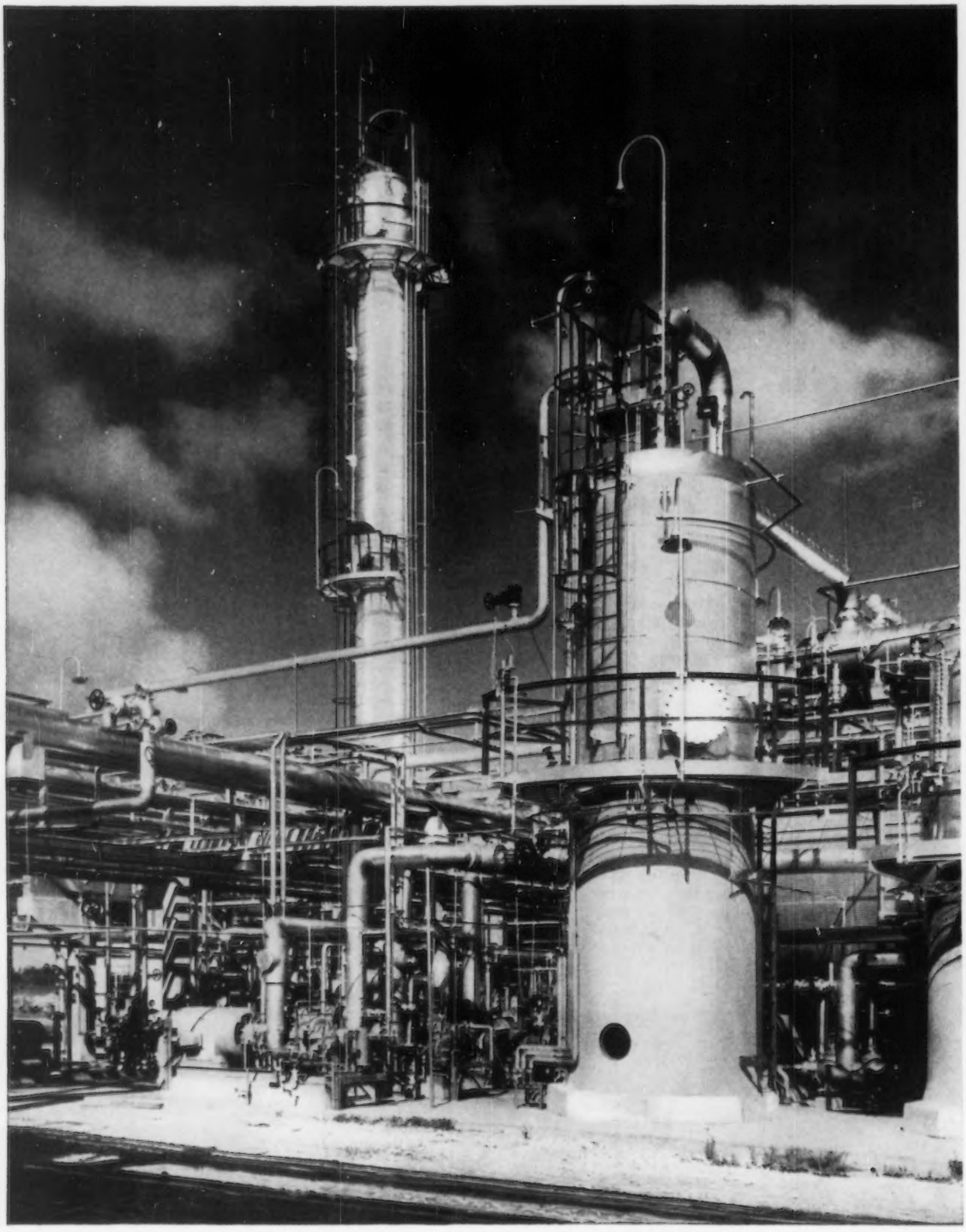
Series 1380
Box-Type Counter (Ratchet, Revolution, or Geared)

4-bank Counter for Radio Transmission Equipment

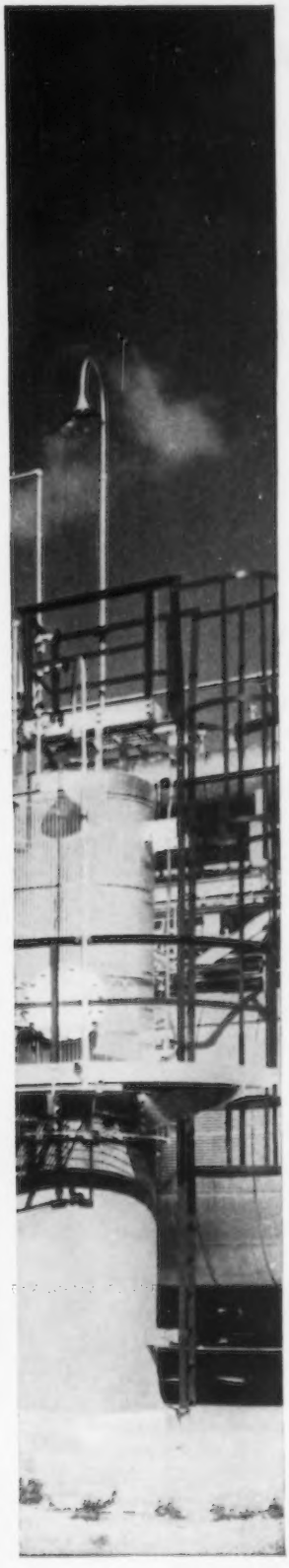


360-degree Bearing Counter

W. R. Grace & Co.'s 50,000,000 pound



high density polyethylene plant now in commercial production



* Multi-million dollar facility to produce GREX, the new high strength plastic resin.

* W. R. Grace & Co., Polymer Chemicals Division, reports GREX substantially improved over other resins, promising new horizons for plastics.

W. R. Grace & Co., Polymer Chemicals Division, recently put into commercial operation its multi-million dollar plant at Baton Rouge, Louisiana. First product is GREX, brand-new high density polyethylene. 50,000,000 pound annual capacity makes this the world's largest plant of its kind to come on stream as an integrated operating unit.

For several months, plastic fabricators have been testing and evaluating quantities of GREX with excellent results. Now, with this new plant, GREX is immediately available for large-scale commercial application.

"NEW CHEMICAL PRODUCT"

Officials of W. R. Grace & Co. express enthusiasm over the possibilities GREX offers the plastics industry, characterizing GREX as "plastic of tomorrow" and "new concept in plastics." According to Mr. T. T. Miller, Polymer President, "GREX differs from other plastics to such a degree, it merits being called a new chemical product."

Exceptional toughness and resistance to extremes of heat and cold are the outstanding property improvements to be found in GREX. Resistance to chemicals, impermeability to moisture vapor, good electrical characteristics, and rigidity are other property areas in which GREX excels. This new material can be injection molded, extruded, compression molded, blow molded, calendered, vacuum formed and foamed. It can be machined, punched, drilled, welded and heat sealed.

VERSATILITY CITED

What does this mean to the plastics industry? "GREX," explains Mr. Miller, "gives the fabricator a quality resin with outstanding versatility. GREX permits him to convert ideas for completely new plastic products into selling items. And by switching to GREX, he can upgrade his present plastic products.

The Polymer Chemicals Division laboratories at Clifton, N. J. include a full line of commercial size plastic fabrication equipment for development purposes. Here, a trained and seasoned technical staff works with Grace customers to learn what plastic products can be better-made with GREX, to uncover new uses for plastics, and to discover more efficient fabrication techniques. The Grace technical staff have also proved their ability to help a customer in his own plant.

OFFER MARKETING SUPPORT

The makers of GREX extend this support to the marketing of GREX products as well. Grace merchandising experts will work with fabricators, and through them, with customers, to help search out their most promising markets. Then, Grace will collaborate on sales and promotion planning to achieve increased sales.

Mr. Miller emphasizes that GREX is expected to make substantial gains in markets now dominated by other materials like glass, wood, metal, offering the plastics industry unlimited potential. There is virtually no business that cannot put GREX to good use.

INQUIRIES INVITED

"GREX is a new product with great promise," he declares. "We believe in it to the tune of over $20 million. But more important, we at Grace are willing to work to prove out GREX in actual applications. Anyone interested in GREX has only to write or phone us at our Clifton offices—225 Allwood Road, Clifton, New Jersey, GRegory 2-6000. His inquiry will receive our immediate attention and he can be sure of full cooperation from our entire organization."

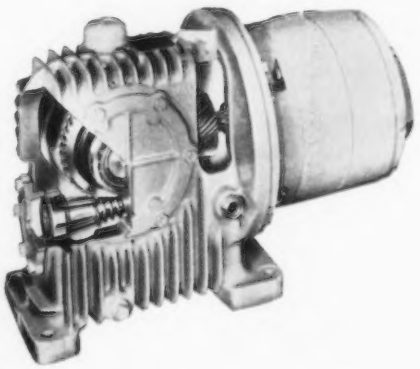
Here's a whole new family of fine GEARMOTORS by Cone-Drive Gears

MOUNT THEM ANYWHERE—FLOOR, WALL, CEILING, OR HANG THEM ON A SHAFT...

. . . there's a Cone-Drive gearmotor for every need. Look at the extensive line of space-saving, power-packed models now available. No matter whether you're faced with floor, wall, ceiling, or shaft mounting at any angle, Cone-Drive Gears has a gearmotor for the job.

It's the most versatile line available PLUS big power capacity in a really compact package. Double-enveloping worm gears, pioneered and proven by Cone-Drive Gears, are combined with a helical primary and extra-large taper roller bearings in a rugged finned housing to give you a power package without equal. You can select any model in any of 27 standard output speeds (7.3 to 525 rpm at 1750 rpm input) in capacities from 1 through 25 horsepower.

Best of all, Cone-Drive gearmotors are priced right down with units that can't deliver nearly as much performance and versatility. Check your nearby Cone-Drive representative or write today for new Catalog 57 containing complete specifications.



Cutaway view of typical Cone-Drive gearmotor illustrates use of double-reduction gear train for increased output power. Note also large taper roller bearings and heavy-ribbed housing.

CONE-DRIVE GEARS

DOUBLE ENVELOPING GEAR SETS & SPEED REDUCERS

Division Michigan Tool Company

7171 E. McNichols Road • Detroit 12, Michigan

Represented in Canada by

COLONIAL TOOL COMPANY, LTD.

Box 190, WALKERVILLE, WINDSOR, ONTARIO

2085 Addington Ave.
MONTREAL

109 Yonge Blvd.
TORONTO

wrenching procedures or for spaces where a blind nut simplifies maintenance. Provides practical flush installation in stock as thin as 0.030 in. The nut, which comes in 4-40, 6-32, and 8-32 threads, is designed with a shank length of 0.040 in. for use in material of 0.30 to 0.050 in. The 8-32 is also designed with a shank of 0.060 in. for use in material of 0.050 in. and greater. Nut and cap are heat and corrosion-resistant steel. **Elastic Stop Nut Corp. of America, Union, N. J.**

Circle 19, inside back cover

Nylon plate . . .

in ⅞ through 1 in. thicknesses are available in Nylon 101 and molybdenum disulphide-filled formulations. Standard width is 10 in. and lengths range to 4 ft. The plate is readily machined on milling and shaping equipment. Among end uses are equipment slides, insulator panels, stripper knives or scraper blade. Properties include high wear resistance and resilience, low surface friction for use where lubrication is undesirable, non-scratching or galling characteristics and sound-deadening qualities. **Polymer Corp. of Penna., 2140 Fairmont Ave., Reading, Penna.**

Circle 20, inside back cover

S-section sheave . . .

permits wider speed changes and increased horsepower-transmitting capacity. Has a range of 5.5 in. min to 120 in. max. Single-groove S-section sheave requires no more mounting space than the smaller R-section one-groove sheave. **Allis-Chalmers Mfg. Co., Milwaukee 1.**

Circle 21, inside back cover

Teflon high-pressure hose . . .

has spiral-wrap construction for resistance to impulse fatigue and lasting strength. Designed originally for 3000 psi aircraft systems. Spiral constructions prevents wear of stainless steel wire, eliminates wire stress concentration and gives optimum strength

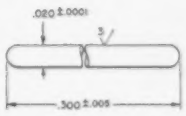
(Continued on page 100)

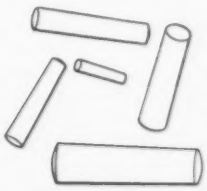
NEWS from Torrington on

SMALL PRECISION METAL PARTS

Custom manufacture of small precision metal parts is the sole job of our Specialties Division . . . and our engineers take particular pride in helping to solve the wide variety of problems involved.

For example, one manufacturer recently turned up with a blueprint and a demand for thousands of meter pivots at a unit cost of less than a penny a piece. To give the long and trouble-free service required, this vital meter part was to be made of stainless steel with high accuracy on OD, close tolerances and a good microfinish. It was to be heat-treated to give the best wear characteristics. Our Specialties engineers worked on the problem in cooperation with the manufacturer . . . and Torrington engineering and production facilities did the rest.





A Specialties engineer received a call from a business machine manufacturer—could we handle a big contract for taper pins on a production schedule calling for many thousands of pins per week? Torrington's capacity is 8-10 *million* small precision parts *per day* . . . taper pins have now joined the many other parts currently rolling off our machines.

We were recently approached by a manufacturer requiring a very large volume of textile machine parts at minimum cost. His own facilities were incapable of producing the parts within the cost limitation, particularly since heat treating and very accurate grinding would be necessary to give the part its long service properties. After discussing the problem from all its aspects, our Specialties engineers decided to fabricate the part by other means than conventional screw machining, thus eliminating cutting while at the same time lowering material costs. Unit cost, quality and production requirements are well within the limitations set.

If you have similar problems involving custom-built small precision metal parts in large quantities, just circle our number on the reply card. Or better still, have your Purchasing Agent call in our area salesman, or write direct to

The Torrington Company, Specialties Division,
230 Field Street, Torrington, Conn.

TORRINGTON

SPECIAL METAL PARTS

Makers of Torrington Needle Bearings

assistant ENGINEER available

His name is STANPAT, and though he is not human he can swallow up your tedious re-drawing and re-lettering of standard and repetitive blueprint items for 24 hours a day if need be—without tiring. STANPAT is the remarkable tri-acetate sheet that is pre-printed with your specification and revision boxes, standard symbols, sub-assemblies, components and cross-sections . . . with adhesive front or back, waiting to be pressed into position in 15 seconds! Reproductions are unusually crisp and clear, guaranteed not to wrinkle, dry out or come off. STANPAT saves hundreds of hours in drafting time and money, allowing the engineer more time for creative work.

Already employed in numerous firms, STANPAT can go to work for you, too! Send us your drawing details now for quotation and free sample, no obligation.

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1 to use:
PEEL the tri-acetate adhesive from its backing.
2 PLACE the tri-acetate in position on the tracing.
PRESS into position, will not wrinkle or come off.
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STANPAT CO.
Whitestone 57, N. Y.
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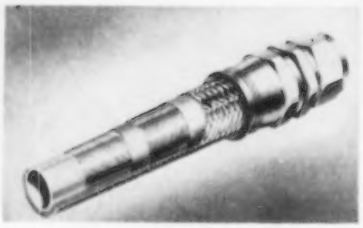
STANPAT CO., Whitestone 57, N. Y., U. S. A.
Phone: FLushing 9-1693-1611

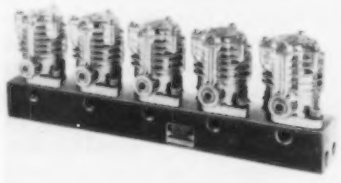
☐ Please quote on enclosed samples. Dept. PE-24
☐ Kindly send me STANPAT literature and samples.

Name_____
Title_____
Company_____
Address_____



without sacrificing flexibility. Metal-to-metal line seal in the fitting, combined with a lip seal formed by Teflon tube between nipple and fitting sleeves, provides leakproof fitting. Functions in temperatures from —100 to 500 F. **Aeroquip Corp., Jackson, Mich.**

Circle 22, inside back cover



Multiple-station manifolds . . .

for mounting solenoid pilot valves without separate sub-bases. Provides centralized valve-panel installations. A centralized filtering and lubricating air supply can be used with the manifolds, offered in two, three, four and five-station types. Common inlet, exhaust and individual cylinder ports are tapped ¼ in. NPT. Conduit outlets are ½ in. NPT. Manifolds have three tapped holes on the underside for mounting and accommodate either three-way normally open or three-way normally closed pilot valves in unmixed groups. Made of aluminum alloy bar stock. **Valvair Corp., 454 Morgan Ave., Akron 11.**

Circle 23, inside back cover

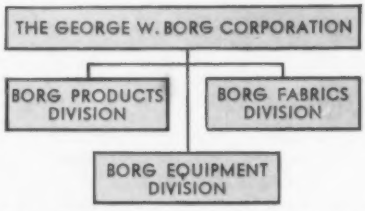
Continuous-duty motors . . .

have good weight-power ratio. Rated 0.10 hp, the motors weigh 17 oz. and operate on ac supply of 200 v, 400 cps, motors are four-pole, three-phase continuous duty, 11,500 rpm. They meet all applicable military specs. Applications include drive motors for instruments, cameras, fans, pumps or any continuous-duty use requir-

(Continued on page 104)

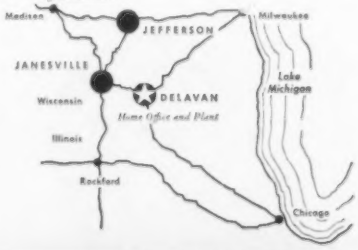
WHO IS BORG?

George W. Borg, who founded this corporation, is the "Mr. Clutch" who started with Borg & Beck. He then helped organize the Borg-Warner Corporation of which he became president. Later he served as chairman of the board until he resigned to devote his full attention to The George W. Borg Corporation.



The George W. Borg Corporation is comprised of three divisions

- **Borg Products Division**
  Manufactures automotive clocks.
- **Borg Fabrics Division**
  Manufactures deep-pile fabrics best known of this line is the fashionable "Borgana" fabric.
- **Borg Equipment Division**
  Manufactures Micropots (precision potentiometers), Microdials (precision turn-counting dials), instrument motors, frequency standards, aircraft navigational instruments and components for systems.



HOW BORG EQUIPMENT DIVISION CAN HELP YOU . . .

Borg's background of experience will save you time and money by helping you solve design and production problems of electronic components. Whether you are faced with a special problem or interested in a standard component, call Borg Equipment Division for an economically sound solution. Write today for catalog BED-A56.

BORG *Built by Borg*
MOTORS
MICROPOTS
MICRODIALS

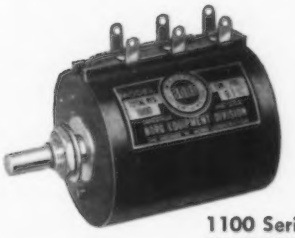
BORG EQUIPMENT DIVISION
THE GEORGE W. BORG CORPORATION
JANESVILLE, WISCONSIN

Why Gamble?

THERE'S A BORG MICROPOT® TO MEET YOUR EXACT SPECIFICATIONS!

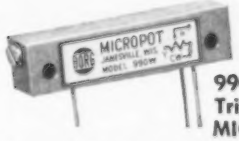
BORG MICROPOTS... the Ultimate in Multi-Turn Precision Potentiometers

Borg offers a complete line of high-precision, linear potentiometers called MICROPOTS. Precision is Borg's business . . . that's why MICROPOTS offer so many exclusive advantages. Superior design and production methods make Borg MICROPOTS available in any quantity. Write today for the name of your nearest Borg Jobber or "Tech-Rep."



1100 Series MICROPOTS

A precision MICROPOT that offers your products a price advantage in today's competitive markets. Lug or lead type terminals. Accurate . . . dependable . . . long lived.

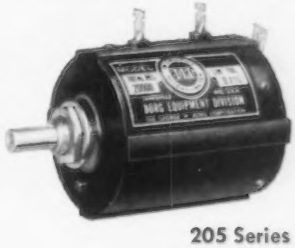


990 Series Trimming MICROPOTS

Small in size, lightweight, rugged and dependable. Three types of terminals . . . printed circuit, solder lugs or insulated wire leads.

900 Series MICROPOTS

Standard ten-turn and three-turn models to fit most special design needs. Extremely accurate and dependable under adverse environmental conditions including severe vibration and shock.



205 Series MICROPOTS

A quality MICROPOT. Designed for both military and commercial applications. Proven in many different mobile and stationary types of electronic circuitry.

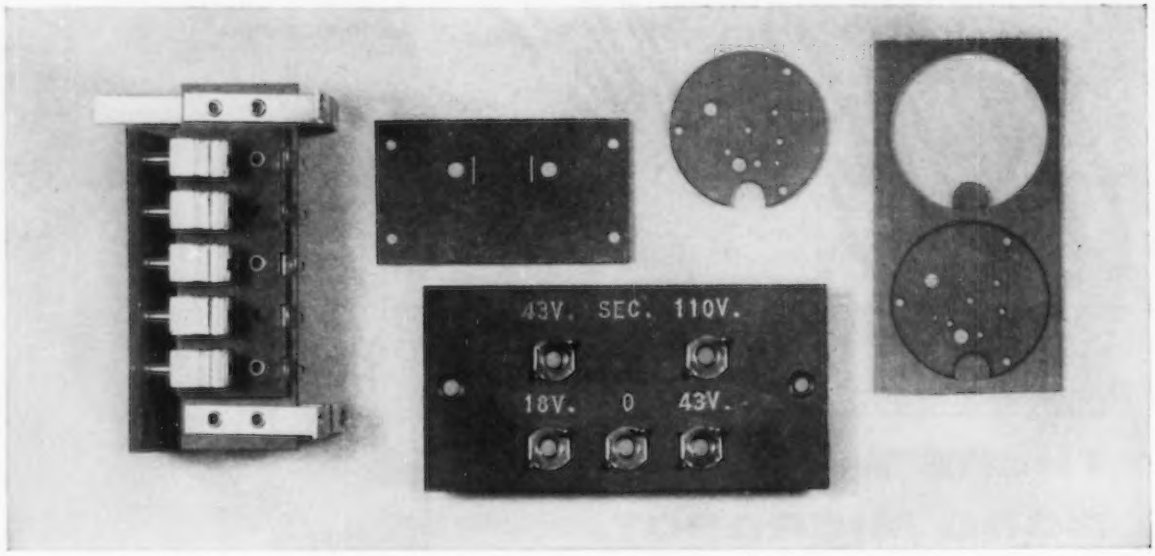
WRITE FOR COMPLETE ENGINEERING DATA • CATALOG BED-A56

BORG EQUIPMENT DIVISION
THE GEORGE W. BORG CORPORATION
JANESVILLE, WISCONSIN

ELECTRONIC – MECHANICAL BORG EQUIPMENT

Built by Borg

MOTORS
MICROPOTS
MICRODIALS



LEADING MANUFACTURERS USE VULCOID. For a punched timer-switch part that operates in oil; for arc chutes in circuit breakers; for the insulation and structural part of an auto-headlight dimmer switch; for a formed electrical switch part carrying 110-volt 60-cycle current; for a mass-produced, 110-volt light-socket part—for these and many more Underwriters-approved parts, CDF Vulcoid is an effective, economical insulation material—good where neither plain fibre nor plain phenolic laminate would suffice.

Fibre gives it high arc-resistance . . .
Aniline resin gives it moisture-resistance

CDF VULCOID

resin-impregnated vulcanized fibre

Vulcoid® is *different*. To the electrical properties of vulcanized fibre we've added the low moisture-absorption of an aniline-type resin with an unusual affinity for cellulose fibers—*all at low cost*. Excellent moisture-resistance (two to four times that of plain vulcanized fibre) helps stabilize Vulcoid's excellent electrical insulating characteristics. Its low cost makes Vulcoid a fine production material for applications of moderate electrical requirements.

Underwriters' approval. Vulcoid is approved by Underwriters' Laboratories as a material for the insulation of current-carrying parts in electrical equipment. It carries the distinctive red and blue thread marking of such materials.

Easy to work. Like vulcanized fibre, Vulcoid is readily drawn or formed into permanent shapes, punched, machined (see illustration above) at low cost. CDF fabrication facilities can give you production quantities of Vulcoid parts to your specifications.

Learn all the advantages of designing around low-cost CDF Vulcoid parts such as arc-deflector spacers, transformer and motor lead bushings, circuit-breaker and transformer barriers, knife-switch guides, transformer coil separators, instrument and contact panels, baseboard receptacles, etc. Ask your CDF man or write for new technical bulletin.

CONTINENTAL-DIAMOND FIBRE

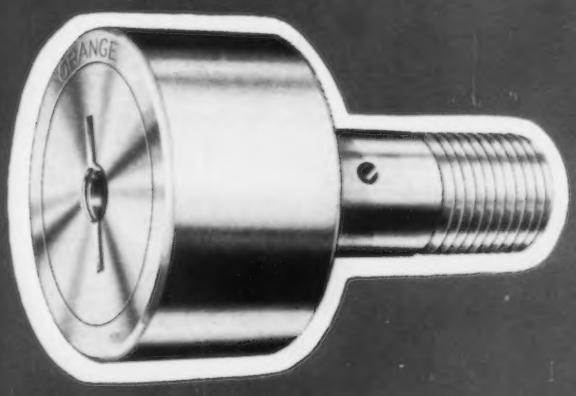
A SUBSIDIARY OF THE Budd COMPANY • NEWARK 40, DEL.

COMPARATIVE PROPERTIES

Property	Commercial Vulcanized Fibre 1/16"	Paper Base (XX) Phenolic 1/16"	VULCOID 1/16"	1/8"	1/4"	1/2"	3/4"	1"
Arc Resistance, seconds	140	4	110	110	110	110	110	110
Specific Gravity	1.25	1.35	1.35	1.35	1.35	1.30	1.20	1.10
Moisture Absorption, % 24 hours	60	1.4	30	15	6	4	4	4 8
Tensile Strength, thousands of psi. —MD CD	11	12 10	12.5 7.5	12 7.5	11 7	9 6.5	8.5 6	5.5 12
Flexural Strength, thousands of psi. —MD CD	16	19 17	24 19	23 17	20 16	16 13	14 11	9 60
Shearing Strength, thousands of psi. —MD CD	8.5 8	14 12	14 12	12.5 11	12 10			
Compressive Strength, flatwise thousands of psi.	25	34	36	36	36			
Izod Impact Strength MD (Edgewise) Ft. lbs. per inch of notch	2.0	0.50*	1.2	1.2	1.2	1.2		
Dielectric Strength, VPM Perpendicular to surface	175	700	475	425	275	170	100	

NOTE: ASTM test methods used for Specific Gravity, Moisture Absorption, Arc Resistance, Tensile, Flexural, Compressive, and Dielectric Strength.

High radial load-carrying capacity and maximum shock resistance for your ...cam activated ...support, or ...track applications



TYPE S—STANDARD STUD

ORANGE CAM FOLLOWERS

The quality of Orange Cam Followers has been well known to industry for many years. They have given unusual performance in many applications. A complete line of Orange Cam Followers is now offered to all manufacturers requiring maximum protection for cam-action and similar mechanisms.

FEATURES

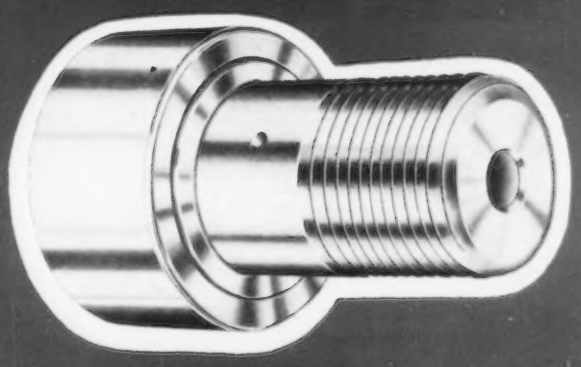
Heavy-sectioned outer race is made of through-hardened, precision-ground, high quality bearing steel.

Small diameter rollers are made of the same high quality bearing steel, electronically gauged for uniformity of size.

Studs are made of high grade steel, induction heat-treated for maximum hardness of the roller track, with core toughness to withstand high shock loads.

Lubrication. Conventional passages are provided for use with drive type fittings, or may be sealed with plugs furnished.

Cam Yoke Rollers are also available, and both types can be provided with seals for special applications. Chrome and cadmium plating, or black oxide finishes also can be supplied.



TYPE H—HEAVY DUTY STUD

A heavy duty stud is available to afford greater shear resistance of the stem where severe operating conditions exist.

Choice of 22 standard sizes from ½" to 4" O. D.

WRITE for 40-page Engineering Manual giving full details on Orange Cam Followers and complete line of Orange Roller Bearings.

ORANGE ROLLER BEARINGS

ORANGE ROLLER BEARING CO., Inc.
551 Main Street, Orange, N. J.

Needle Bearings — Staggered Roller Bearings
Journal Roller Bearings — Thrust Roller Bearings
Cam Followers

REEVES® *Vari-Speed MOTODRIVE*

● A complete variable speed power package for the equipment you design for use in highly corrosive atmospheres.

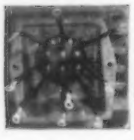
Available from ¼ through 5 hp., the 100, 200 and 300 size Motodrives are resistant to most acids, gasses and corrosive dusts. They feature a wide speed range . . . up to 10:1 with gear ratios from 1.17:1 to 195:1 . . . and provide infinitely variable speeds in hundreds of standard assemblies to fit nearly any space requirement.

Corrosion-Proof Disc Assemblies

Corrosion resistant cast iron; Exclusive REEVES "close grooving"—for positive disc lubrication.

Corrosion-Proof Gear Reducers

Cast iron gearbox and head; shaft oil seal—double lip neoprene; leak proof vent plug.



Corrosion-Proof Motor

Solid cast iron housing and fan—fully sealed cast iron conduit box—motor lead gasket seals off motor windings.

Fully sealed cast iron Motodrive case and inspection plates protect operating internals—lifetime stainless steel nameplates and identification plates—zinc plated Hexhead capscrews throughout. Write for Bulletin K34-M578.

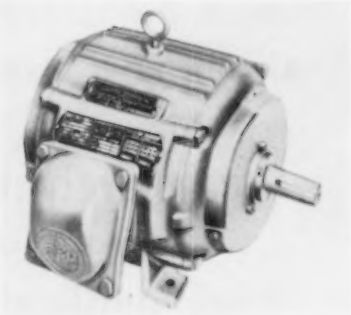
REEVES PULLEY COMPANY

Division of **RELIANCE** ELECTRIC AND ENGINEERING CO.

Columbus, Indiana

ing an induction motor of this type. **Task Corp., 1009 E. Vermont Ave., Anaheim, Calif.**

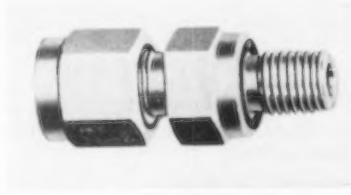
Circle 24, inside back cover



Explosionproof motors . . .

in fan-cooled and nonventilated models meet NEMA standards and are UL-approved for Class I group D, Class II group E, F and G. Fan-cooled ratings are 1½ to 30 hp. Non-ventilated motors are available in 1½ hp ratings and lower. Conduit box can be rotated around the motor periphery to any of four positions 90° apart. All mechanical parts are cast iron, except external fan, slingers, shaft, bearings and hardware. **Fairbanks, Morse & Co., Beloit, Wis.**

Circle 25, inside back cover



Vacuum O-ring fittings . . .

were developed for high and low-pressure systems and for critical applications where even minute leaks cannot be tolerated. Consists of a straight-thread male connector and adapter. The O-ring built into the body of the fittings is said to permit a high vacuum seal against any flat surface. Available in sizes ranging from $\frac{1}{16}$ to 1 in. **Crawford Fitting Co., 884 E. 140th St., Cleveland 10.**

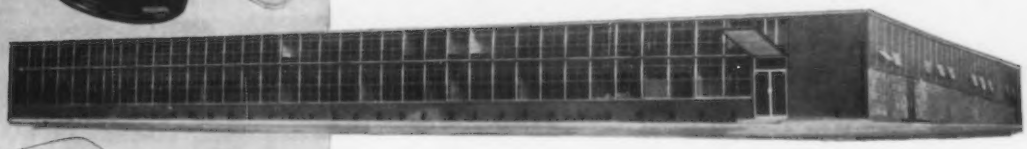
Circle 26, inside back cover

Resilient fan hub . . .

combines low noise level with high starting torque. Reduces 120-cps noise originating in ac drive motors and withstands 20 in-lb of starting torque. Hub consists of two ribbed neoprene pieces and a hub retainer. Permits axial stability, more

(Continued on page 106)

INJECTION MOLDING BY CONSOLIDATED



Scranton, Pennsylvania:

The caption takes on added meaning with the opening of our fine new plant, exclusively devoted to injection molding. Located in Lackawanna Valley's Industrial Park, it contains 80,000 square feet of space on one floor and houses 23 injection presses plus unexcelled spray painting, metallizing, and other decorating and finishing facilities. There will be no better injection plant in the East—and no more experienced or knowledgeable production staff.

Binghamton, New York:

New York State manufacturers now enjoy the added convenience of this new addition to our injection molding facilities. Twenty thousand square feet of floor space, seven modern injection presses, new dimensions in decorating and finishing—all these and a sound organization, too, are right on the spot to serve you better.

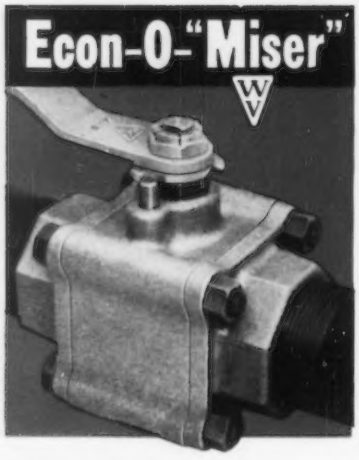
Whatever your injection molding need, Consolidated has the wherewithal to serve you to your complete satisfaction. Two new plants in operation have equipped us better than ever before to handle any injection molding job. Why don't you see for yourself what our expansion—backed by long experience—can mean to you?

At Consolidated, Everything is Modern Except Our Old-Fashioned Pride in Craftsmanship

"Your Blueprint in Plastics Since 1874"

CONSOLIDATED MOLDED PRODUCTS CORPORATION

Scranton, Pa. and Binghamton, N.Y.



Worcester's New Econ-O-"Miser" Ball Valve* is BOTH

VALVE and UNION

The costs of a union and installing it are eliminated. Add to this the longer operating life of the Econ-O-"Miser", the time and materials savings of *in-line maintenance*, and you get performance unmatched by *any* valve at *any* price.

The Econ-O-"Miser" is available in Bronze, Aluminum, Aluminum Bronze, Forged Carbon Steel, types 303 and 316 Stainless Steel. Seat and seal materials available: Teflon, Buna-N and Neoprene (others available on request.)

The many combinations of body and seat seal materials allow handling of exceptionally wide range of media.

Other Outstanding Features

- Compact for ease of installation
- Positive leakproof shut-off
- **In-line maintenance** permits quick, easy inexpensive repairs
- Two-way flow allows application of pressure or vacuum to either side of valve
- Quarter turn operation — readily adaptable to remote control
- Visual determination of OPEN — CLOSED positions — No manual check needed
- Round flow through the valve — minimum pressure loss and turbulence
- "Wiper-action" of resilient seat against ball eliminates abrasive wear due to foreign materials in media . . . assures leak-proof seal . . . long operating life

* Pat. Pending

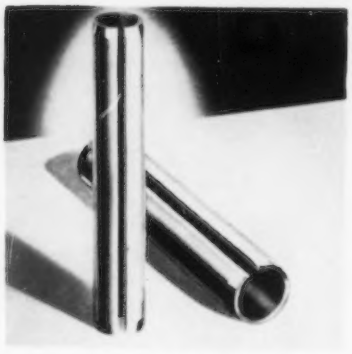
Write for full particulars

WORCESTER VALVE CO., Inc.

18 Parker Street, Worcester, Mass.

positive drive than conventional rubber hubs with eight driving lugs engaging the spider and hub retainer, and uniform compressibility of the two resilient pieces. **Torrington Mfg. Co., Torrington, Conn.**

Circle 27, inside back cover



Beryllium copper spring pins . . . are axially slotted and lock by spring action when driven into an ordinary hole. Made from 0.062 to 0.250 in. dia. Lengths range from $\frac{1}{8}$ to 4 in. Length tolerances range from ± 0.015 in. in smallest sizes to ± 0.030 in. in largest sizes. **Standard Pressed Steel Co., Box 545, Jenkintown, Penna.**

Circle 28, inside back cover

Rectifier power supply . . . provides a stepless controllable output of from zero to 32 v dc, with a continuous duty, full-load rating of 40 amp. Ripple is held to 0.5% throughout range. A safety factor permits continuous operation at 125% of rated current. Convection-

(Continued on page 108)

MODERN ELECTRONIC ENGINEERING GIVES PRECISE MOTOR SPEED CONTROL

1/100 — 10 H. P.

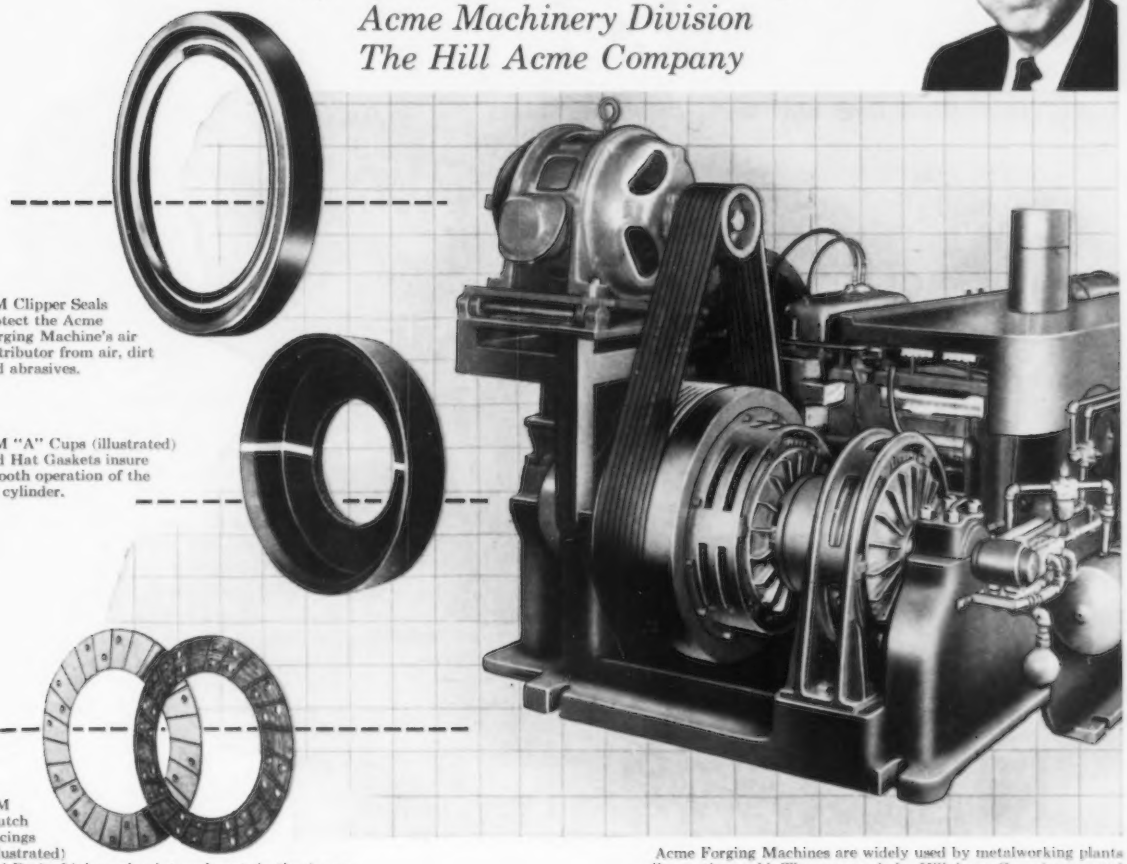
Modern industrial electronic engineering has been coordinated with electric motor design to provide a versatile means for obtaining the full possible advantage of speed control in DC motors while operated from the regular alternating current power line. Grid controlled "Thyratron" tubes are utilized for power controlled stepless variation to supply motor armature power. Patented feedback, or "Servo" circuits provide constant torque capability over wide speed ranges of as high as 60 to 1 in some models and a minimum of 20 to 1 in others.

Servospeed

DIV. of ELECTRO DEVICES, Inc.
4 Godwin Ave., Paterson, N. J.
ARmory 4-8989

"Customer satisfaction hit a new high when we redesigned Acme forging machines with J-M Packings and Friction Materials,"

says M. W. Lamprecht, Chief Engineer
Acme Machinery Division
The Hill Acme Company



J-M Clipper Seals protect the Acme Forging Machine's air distributor from air, dirt and abrasives.

J-M "A" Cups (illustrated) and Hat Gaskets insure smooth operation of the air cylinder.

J-M Clutch Facings (illustrated) and Brake Linings play integral parts in the Acme Forging Machine's cushion drive mechanism.

Acme Forging Machines are widely used by metalworking plants all over the world. They are made by Hill Acme Co., pioneers and leaders in construction and design of modern forging machines.

J-M products defy extreme thermal and mechanical shock for dependable performance and long life

In terms of thermal and mechanical shock and the constant presence of dirt, chips and other abrasives, Acme Forging Machines provide one of the most rugged tests ever devised for packings and friction materials. In more than 20 years of service, Johns-Manville products have achieved an enviable record with Acme users. Performance has been more than satisfactory in every way and replacement has been held to the minimum.

Johns-Manville makes a complete line of packings, gaskets, asbestos textiles, brake linings, clutch facings, transmission bands and industrial friction materials. Chances are one or more of these products may provide the answer to your design problems. For further information call your local J-M sales office or write Johns-Manville, Box 14, New York 16, N. Y. In Canada, Port Credit, Ontario.

JOHNS-MANVILLE

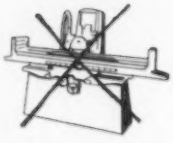
Have you seen our

BIG NOs?

save time and cost with *Laminum* Shims

NO machining

NO grinding



NO counting

NO stacking

NO miking

and ***NO*** *dirt between layers— ever*

LAMINATED SHIMS OF

LAMINUM®

SURFACE BONDED . . . THEY *peel* FOR ADJUSTMENT

And *only in Laminum* are laminated, surface-bonded shims available *in all four materials* as shown below.

Laminated Shims of **LAMINUM** now available in

STAINLESS STEEL with laminations of .002" or .003"	**LOW CARBON STEEL** with laminations of .002" or .003"
BRASS with laminations of .002" or .003"	**ALUMINUM** with laminations of .003" only

LAMINATED SHIM COMPANY, INC.

Shim headquarters since 1913

1402 Union Street, Glenbrook, Conn.

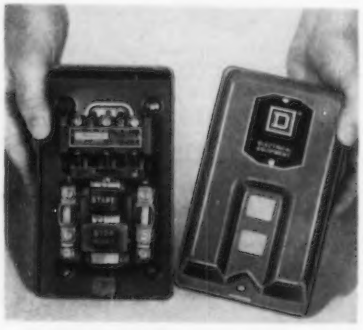
cooled unit is housed in a ventilated steel cabinet, 22 x 14 x 15 in. Weight is 140 lb. Unit may also be rack mounted. **Opad Electric Co., 69 Murray St., New York 7.**

Circle 29, inside back cover

Variable transformer . . .

will deliver 1.5 amp at any brush setting, even full overvoltage. Brush arm carries no current and provides completely independent contact pressure. A ceramic hub aligns and mounts brush arm and provides 3000-v-ac insulation between the shaft assembly and parts at line potential. Internal stop eliminates possibility of damage to brush and brush arm. A reversible, direct-reading dial is calibrated to 120 v on one side and 132 on the other. It permits direct setting to desired voltage for line or overvoltage connection. **Ohmite Mfg. Co., 3667 Howard St., Skokie, Ill.**

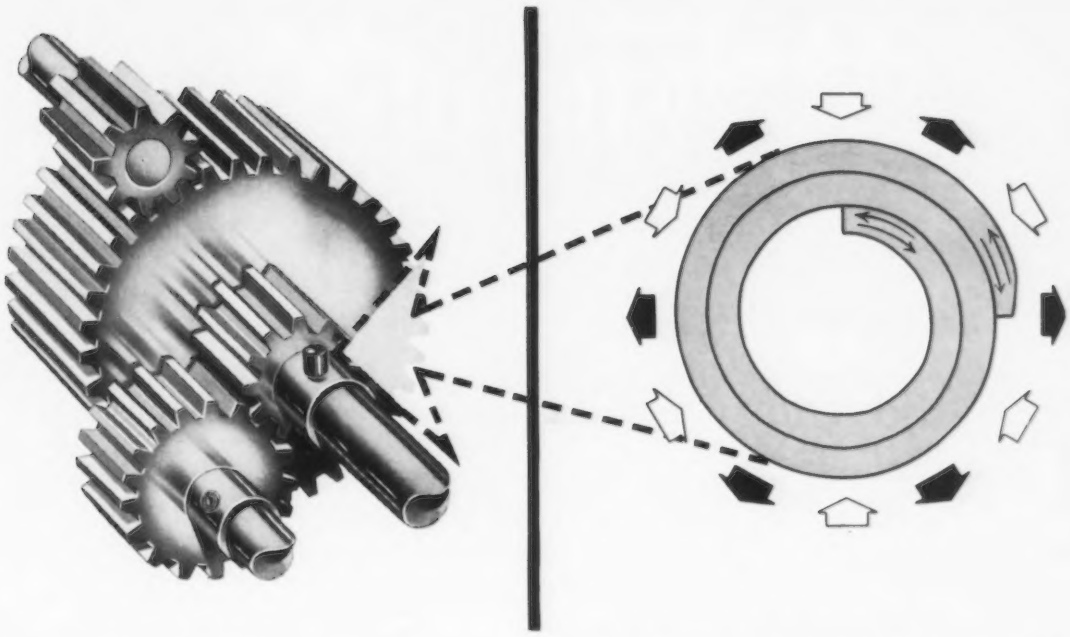
Circle 30, inside back cover



Manual starters . . .

in NEMA size 0 and 1 for control of motors to 7½ hp are rated to 600 v ac or 250 v dc. Offered in two, three or four-pole construction. An open version and a line of enclosed models are available. Design features a heavy-duty, toggle-action-operating mechanism that gives positive snap-action opening and closing of the contacts. Overload protection is provided by melting alloy type relays.

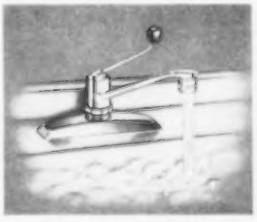
(Continued on page 112)



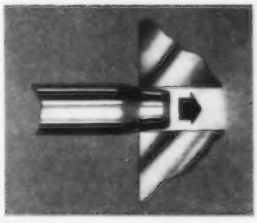
This spring pin's strength . . . comes from true spring *coils*

Full 360° radial spring action gives SPIROL true spring pins the ability to withstand repeated, heavy shock and vibration. When compressed, the unique spiral coils distribute stress evenly throughout the cross-section. There is *no stress concentration* at any point — no critical cross-section even with non-heat-treated metals. SPIROL's novel design gives you *all* the *cost-saving* benefits of a true spring pin.

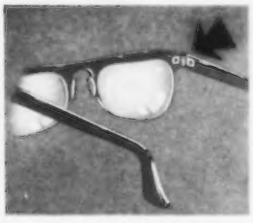
SPIROL gives these unique advantages



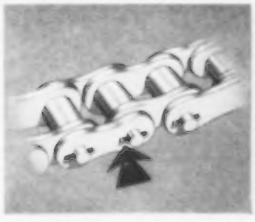
Non-heat-treated metals — such as low-cost brass, copper, nickel stainless steel — can be used in SPIROL true spring pins. Less resilient metals flex without failure, because there is no concentration of stress.



Wider hole tolerances eliminate reaming, reduce drilling rejects, cut production costs. Both plus *and* minus tolerances are allowed because of SPIROL spring pin's greater flexibility in expansion and compression.



Miniature sizes retain flexibility and strength of the spiral cross-section. SPIROL is the only spring-type pin made in miniature diameters: 1/32" — .039" — 3/64" — .052". Standard diameters up to 1/2" in stock.



Shock resistance — extremely high resistance to shock, shear, and vibration permits use of "medium duty" SPIROL pins in the majority of applications. Heavy and light duty SPIROL pins are also available in stock.

FREE! *Write for complete literature on* SPIROL *spring pins, including price list.*

®SPIROL *the true spring* PIN

C. E. M. COMPANY • 94 SCHOOL STREET • DANIELSON, CONNECTICUT Phone: PRescott 4-2411

Any similarity to a real-life company is purely intentional

How did they use their beans in Boston to cut forming rejects?

A couple of years ago, Otto Motive, super sales engineer of East Boston, Mass., began to eye a new prospect.

Thought he, "As an account, that Supercrate V-8 looks great. They buy a lot of parts. It sure would be peachy—and profitable—to land that plum!"

And, by golly, Otto did get a contract — to furnish wire-wheel units of 25-gauge stainless.

He also got *more* than he bargained for. Sleepless nights, for example. Because — though tempus fugited, production of the wire-wheel units didn't.

It seems that the boys in Otto's shop had trouble forming the hub-cap sections of the units. The stainless scored in the die. Rejects piled up. The scrap pile became something to behold. Delayed delivery dates caused delirium.

Then someone suggested trying dies made from Ampco Metal Grade 24 (a just cause for a raise, if we've ever heard of one!).

Rejects dropped off to practically nothing. Which is no surprise to us. Dies made from Ampco Metal have done as much for many a shop drawing or forming stainless or other clean metals—have made possible real savings.

And they can do as much for *you*. You can count on that!

Ampco Metal dies have an exceptionally low coefficient of friction. They don't load, gall, or scratch the work. They hold close tolerances longer.

You make a better product with fewer costly finishing operations. You cut scrap loss.

You reduce downtime, also. Ampco Metal dies have little or no pickup — you get far longer runs than with steel dies without redressing.

An Ampco stocking distributor near you carries 70 sizes of Ampco Metal die blanks — solid rounds, rectangles, and centrifugually cast rings. Call him.

AMPCO ®

If you don't know who your Ampco distributor is, write us for his name. *Ampco Metal, Inc., Dept. PE-2, Milwaukee 46, Wisconsin. (West Coast Plant: Burbank, California).*

AMPCO METAL

The metal without an equal

RM-6

WICHITA CLUTCHES

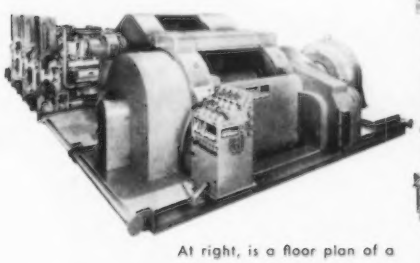
– SO GOOD OVER 4,000 USED ON WILSON DRILLING RIGS and WINCHES!

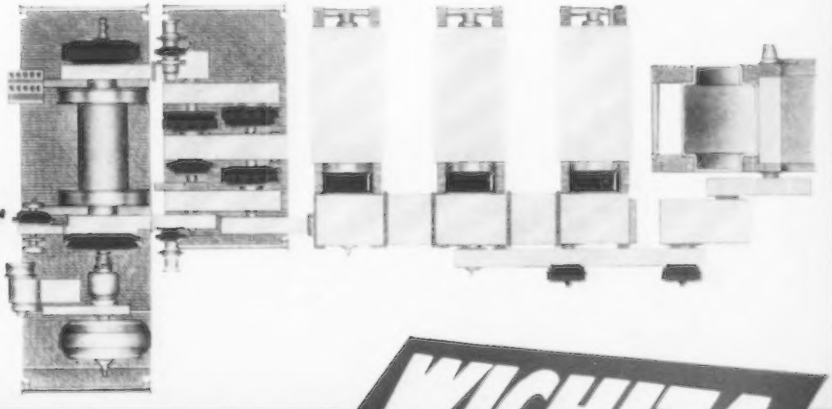
Drilling rigs and winches receive just about the most abuse of any type of major machinery which is one reason why the clutches have to be the best. For the past 10 years Wilson has standarized on Wichita Clutches. While operating in every type of weather, in all parts of the world, and under the most severe conditions, Wichita Clutches have performed perfectly. A Wichita Air-Tube Disc Clutch has proved to be one of the major components on Wilson drilling Rigs with as many as 14 being used on each rig.

This simple, compact, powerful, trouble-free, Air-Tube Friction Clutch makes possible convenient remote control operations, smoother and faster starting and stopping. It also means longer service at a lower cost because it requires very little maintenance.

You Name it . . . Wherever a Clutch is needed . . . There's a Wichita Clutch to meet the need.

Below is a view of one of the huge Wilson Drilling Rigs.





At right, is a floor plan of a Wilson rig showing the use of fourteen Wichita Clutches.

Contact your nearest Wichita Engineer!

Brehm-Laner, Inc., Detroit, Michigan
L. H. Fremont, Cincinnati, Ohio
W. G. Kerr Company, Pittsburgh, Pa.
Smith-Keser & Co., Avon, Conn., Philadelphia 44, Pa., and New York, N.Y.
Frank W. Yarline Co., Chicago, Illinois
Larry W. McDowell, Long Beach, California
Andrew T. Lobel, Denver, Colorado
Robert R. King Co., Cleveland, Ohio
R. E. Kunz, Seattle 4, Washington
W. G. Ballantyne Co., Portland 4, Oregon
Allied Transmission Equipment Co., Kansas City 8, Missouri
Norman Williams, Houston, Texas
Donald E. Harman, Dallas, Texas
C. Arthur Weaver, Richmond, Virginia
Malcolm S. Cone, Memphis, Tennessee
Dominion Power Press Equipment, Ltd., Burlington, Ontario, Canada
Bates Sales Co., St. Louis 1, Missouri

WICHITA Clutch COMPANY, INC.
WICHITA FALLS, TEXAS, U.S.A.

...for a standard line of motors adaptable to hundreds of applications

YOU CAN ALWAYS

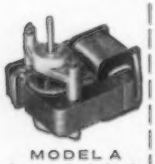
RELY on GI

Fractional H. P. Motors

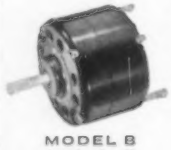
1/40 H. P. to 1/1100 H. P.

General Industries' standard line of motors is adaptable, with slight variations, to literally thousands of applications. This means that your motor requirements can most likely be met without additional time-consuming engineering.

If you are currently using fractional horsepower motors, or are planning a product that calls for their use, phone or write General Industries. We'll gladly make recommendations — without obligation.



MODEL A
2-pole, shaded pole AC Induction Type



MODEL B
4-pole, 4-coil shaded pole AC Induction Type

MODEL E
4-pole, shaded pole AC Induction Type

MODEL D
4-pole, 4-coil shaded pole AC Induction Type

Write for Complete Specifications and Quantity Price Quotations TODAY!

THE GENERAL INDUSTRIES CO.

DEPT. GK • ELYRIA, OHIO

Self-centering pushbuttons give visual indication of an overload condition. Pressure wire connectors simplify installation on all wiring terminals. Part kits are available packaged. **Square D Co., 4041 N. Richards St., Milwaukee 12.**

Circle 31, inside back cover

Solenoid valve . . .

may be used on 6 or 12 v dc. Weighs 11 oz and is 2¾ in. long. Valve has straight-through design, ¼-in. pipe connection and may be used as gasoline shutoff. Lists for $12.50. **Beam Products Mfg. Co., 3040 Rosslyn St., Los Angeles 65.**

Circle 32, inside back cover

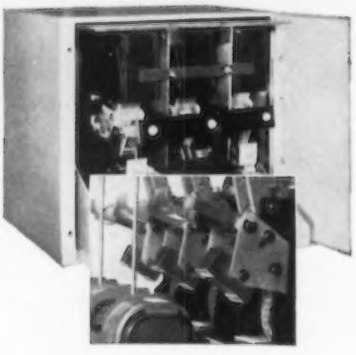
Rotary vane compressors . . .

in sizes from 400 cfh to 6000 cfh at pressures from 1 to 3 psi are air cooled. Line features built-in automatic by-pass regulator that maintains preset delivery pressure at varying outputs. Output may be completely shut off for short periods without causing excessive heating. Units are gastight for handling mixtures of gas and air. A rotor that holds six plastic composition vanes revolves eccentrically to the compressor body. Vanes, sliding in and out of the rotor slots, are the only moving parts other than the rotor. Vanes are low-friction plastic. There are no gears, springs or metal-to-metal contacts. Bear-

(Continued on page 117)

TIPS on using GIBSILOYS

GIBSON CONTACTS *give compact design, top performance in new Cemco "Fusematic" switch*



- **NEW "FUSEMATIC"** switches developed by Cemco Electrical Manufacturing Company, Ltd., of Canada, require electrical contacts of 100,000-amp interrupting capacity.
- **GIBSILOY CONTACTS** were Cemco's choice not only for their high electrical and thermal conductivity but also their low contact resistance, long life, resistance to arc erosion and sticking.
- **GIBSON CONTACTS** can do the same for you. We offer a complete line of contact materials, forms, and assemblies to meet requirements of your electrical product. Contact us to quote on your next job. Our engineers will help you in contact design.

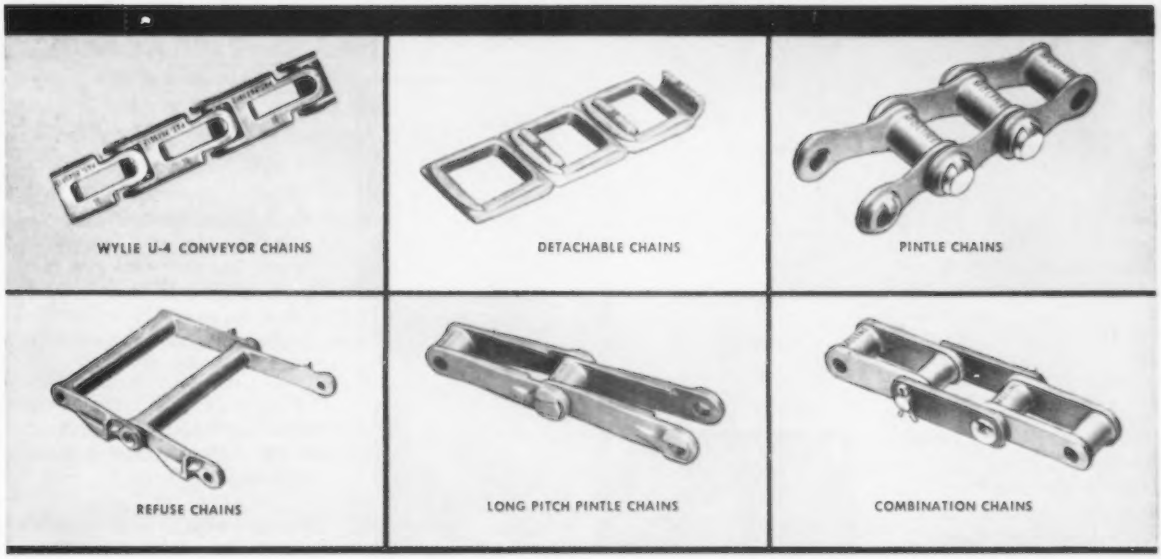
See our catalog in Sweet's Product Design File or write for Gibson Catalog C-520.

Gibsiloy ELECTRICAL CONTACTS

Manufactured by GIBSON ELECTRIC COMPANY

BOX 634, DELMONT, PA.

Moline *makes just one thing– the world's finest Malleable chain*

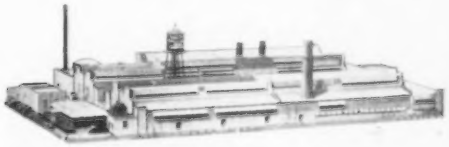


for conveying, elevating and power transmission

SPECIALIZATION makes the difference in Moline Malleable Chain. More than 60 years' concentration on the production of chain makes Moline the chain experts. Moline engineers and technicians confine their efforts to improving chain design and manufacture and to the refinement of production facilities within Moline's two large plants.

That's why you can be absolutely certain that every link bearing the name Moline will give maximum performance and long life... in conveying, elevating and power transmission services.

Specify Moline Chain, malleable or promal, for your equipment. Write today for catalog.



THE HOME OF TRIPLE TESTING!

This completely modern foundry—one of Moline's two large plants—houses fully mechanized production lines and Moline's famous triple testing facilities. Link by link, strand by strand, Moline chains undergo rigid physical testing. They are visually inspected and gauged by experts before being assembled, then stressed to proof strength and shock tested for soundness.

Moline Chains

MOLINE MALLEABLE IRON CO.
ST. CHARLES, ILLINOIS

LEADERS FOR 60 YEARS

Specializing in the manufacture of chain

TIMERS...SPECIAL DELIVERY

Standard or special— Industrial Timer makes rapid deliveries on all models

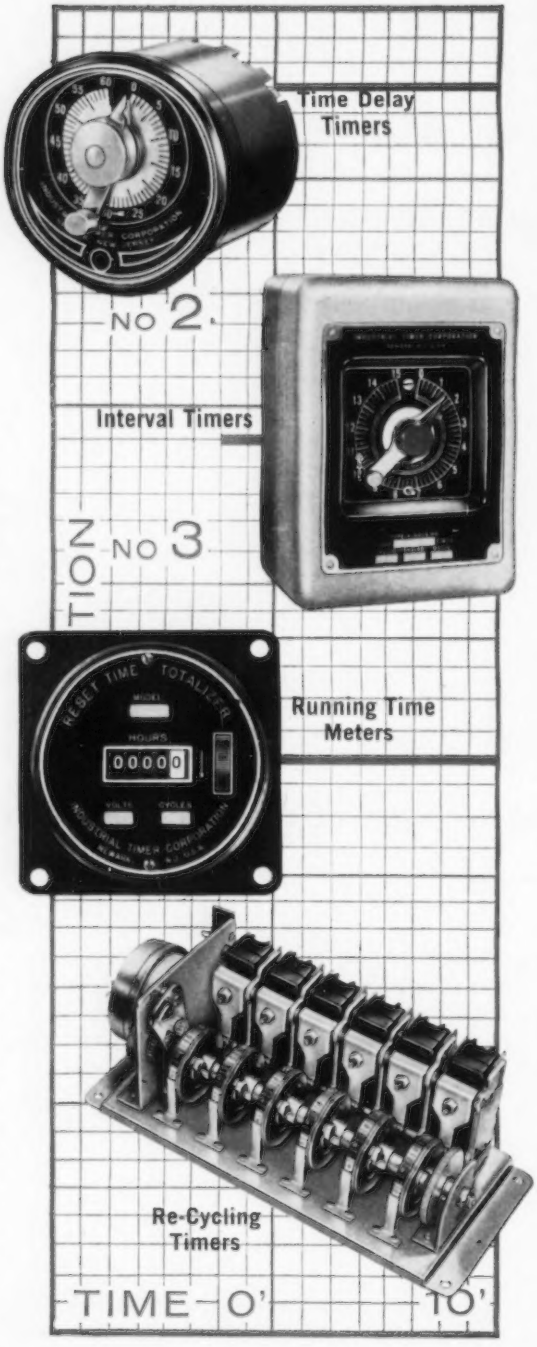
Sometimes you need a standard model timer . . . other times you need a special. Either way we can give you the extra rapid service you may need because of the efficient way we design, manufacture and stock timers for industrial applications.

To meet *all* of the widely varying needs of our customers we manufacture a complete line of timers in the four broad classifications illustrated here:

1. TIME DELAY TIMERS
2. INTERVAL TIMERS
3. RE-CYCLING TIMERS
4. RUNNING TIME METERS

From these we have already developed 20 basic types which can be combined in endless number of ways . . . to date, our engineers have combined them into over 1000 different models. So what might seem to be a special timer requirement to you, will very often be a standard timer in our large stock, and that is the reason we have the ability to fill special orders so quickly. And as far as standard timers are concerned we can give overnight service if necessary.

So, for the utmost in all-round service depend on us for this outstanding combination: deliveries "Immediate on Standards . . . First on Specials".



Speed up your automatic control projects— profit by our timing application experience

No need to let timing problems delay you in your automatic control projects when you can place them with us and get faster solutions. Even though no two automatic control jobs are ever exactly alike, and even though the timer requirements of each are very different we have established an excellent record in helping out in these situations.

20 years of experience in analyzing complex timer applications has provided us with the special knowledge required to give our customers the right answer in near-record time.

Our large stock of standard and combination timers enables us very often to fill orders for these requirements without any time loss because we have already developed so many new combinations specifically for automatic control functions.

Extra special automatic control timer — this calls for original designing. Our engineers will go right to work and get the job done. That's the way we grow and we like it.

Whatever your control problem, you have everything to gain by submitting it to our timer specialists. They'll come up with the answer — almost with the speed of automatic control itself.

Timers that Control the Pulse Beat of Industry

INDUSTRIAL TIMER CORPORATION

INDUSTRIAL TIMER CORPORATION
1415 McCARTER HIGHWAY, NEWARK 4, N. J.

Is your tubing bottleneck shown here?

Bundy Engineers and versatile Bundyweld Tubing can beat the knottiest tubing design problem!

If you think it can't be done with tubing, it's a challenge to Bundy. For years, Bundy Engineers have specialized in working with customers and prospects, solving the insolvable. A unique combination of imagination and experience, plus the extreme versatility of Bundyweld Steel Tubing, has paid off again and again.

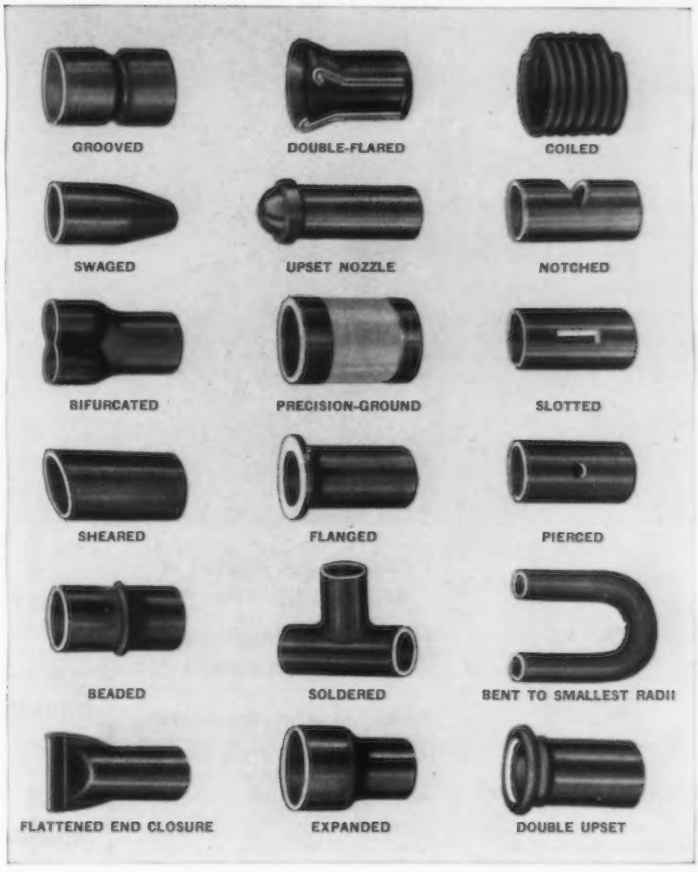
Check first with Bundy for workable solutions to your tubing design problems. Whether you are in the design, developmental, or application stage of your product, Bundy will be glad to work with you. Hundreds of manufacturers have used this Bundy service to advantage.

Bundyweld Tubing offers an unusual combination of properties: high thermal conductivity; high bursting strength; ease of fabrication; and thinner-walled, yet stronger composition. It is the safety standard of the refrigeration industry, and is used in 95% of today's cars, in an average of 20 applications each.

Call, write, or wire us today!

BUNDY TUBING COMPANY

DETROIT 14, MICHIGAN



Shown above are but a few of the fabrication operations which are possible with Bundyweld Steel Tubing. Many of these, and others not shown, were developed through solving a specific problem brought to us by a customer or prospect. Bundy invites you to avail yourself of this design service.

WORLD'S LARGEST PRODUCER OF SMALL-DIAMETER TUBING. AFFILIATED PLANTS IN AUSTRALIA, ENGLAND, FRANCE, ITALY, AND GERMANY

Bundyweld starts as a single strip of copper-coated steel. Then it's
. . . continuously rolled twice around laterally into a tube of uniform thickness and passed
through a furnace. Copper coating fuses with steel. Result . . .
SIZES UP TO ¼" O.D.
Bundyweld, double-walled and brazed through 360° of wall contact.

NOTE the exclusive Bundy-developed beveled edges, which afford a smoother joint, absence of bead, and less chance for any leakage.

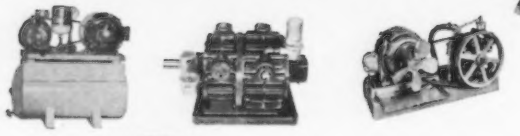
BUNDYWELD TUBING®

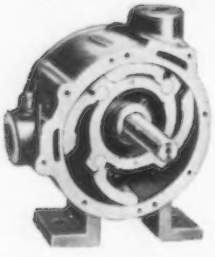
DOUBLE-WALLED FROM A SINGLE STRIP

VACUUM PROBLEM?

LEIMAN
HAS THE ANSWER!

- Over 70 years' experience
- Wide range of types, sizes, models
- Engineering representatives in all industrial centers.





4-WING TYPE. Vacuums to 20" Hg.; pressures to 15 psig.; volume to 162 cfm. Cast iron wings, hinged to pistons, maintain continuous sealed contact with the cast iron cylinder walls by centrifugal force.

- **Consult Leiman engineers on any vacuum application**
- **Install Leiman Vacuum Pumps for "lifetime" dependability**

Vacuum operations are usually critical, requiring a steady, reliable source of rated vacuum. You get this with Leiman Rotary Vacuum Pumps because they are designed to take up their own wear. They have fewer moving parts—and all parts are precision-made of durable cast iron and steel (not composition) to maintain new pump efficiency for 10, 15 and 20 years, without maintenance except oiling.

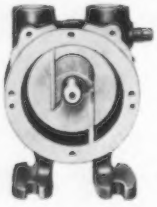
High vacuum, high volume, small space

The simplified Leiman design provides larger air space, permitting use of smaller pumps, slower speeds, less horsepower. Operation is quiet.

Every pump tested!

Each individual Leiman Vacuum Pump is given a long test run before shipment to assure fully rated vacuum, pressure and c.f.m. capacity.

Over half a million Leiman Vacuum Pumps have been installed with utmost satisfaction. Design Leiman dependability into *your* equipment.



2-WING TYPE Vacuums to 29.9" Hg.; pressures to 20 psig.; volume to 40.8 cfm. Automatic wing adjuster forces wear-resistant steel wings to cast iron cylinder walls, preventing sticking or binding, maintaining positive vacuum or pressure.

WRITE for 16-page catalog, plus Application Book showing many "how-to-do-it" blueprints.

LEIMAN BROS., Inc. 107 Christie St., Newark 5, N. J.
Established 1887

LEIMAN Rotary Air and VACUUM PUMPS

cut production time and costs
with **INDUSTRIAL**
RETAINING RINGS

Save material, eliminate costly machining and tooling, speed assembly with precision-made INDUSTRIAL Retaining Rings. They can be re-used over and over again because of their lasting resiliency and sustained circularity.

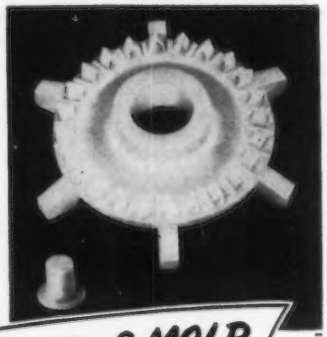
Internal, external and open types are available for immediate delivery in a wide range of sizes and finishes. Open-type rings are also available stacked for speedier assembly.

Write today for free ring samples and catalog.

IRR *Originators of modern retaining ring dispensing*

INDUSTRIAL RETAINING RING COMPANY
Dept. PE-2 57 Cordier Street • Irvington 11, New Jersey

Savings on your first order for moldings will, in many instances more than



COVER COST of MOLD

* New trademark for Du Pont nylon resin

And thereafter you may look for savings on raw materials, machining, and finishing that will cut the production costs of your parts to half . . . or even less.

That is why some of the country's leading manufacturers, like the Briggs and Stratton Corp., look to us for many of their precision-made parts. Pictured above is an oil slinger gear and stop switch button we molded for them of wear-resistant Zytel*. This superior plastic makes for quiet operation, and withstands extreme temperatures.

WE MOLD ALL THERMOPLASTICS—2 TO 175 OZ.

Sinko **SINKO MFG. & TOOL CO.**
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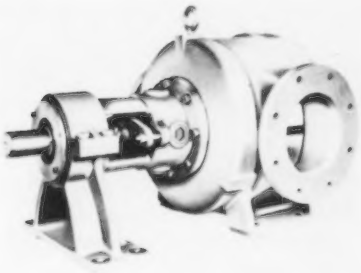
Offices in principal cities throughout the United States

ings are permanently silicone-lubricated. Compressors can be driven by standard V-belt drive with a final driven speed of 750 to 1100 rpm, depending on size of compressor and pressure standard 1750 rpm motor. **Wankee Engineering Co., Inc., 5138 N. 35 St., Milwaukee 9.**

Circle 33, inside back cover



Rotary pump . . .

for viscous and thin liquids has a 1200-gpm capacity for general transfer, metering and services involving pressures to 100 psi. Min sealing surfaces with optimum rotor and idler dimensions for any given viscosity reduce viscous drag, resulting in efficiencies to 90%. Direction of flow may be reversed regardless of shaft rotation. Pump available in various materials. **Seren Machine Products Corp., 1800 W. Fulton St., Chicago 12.**

Circle 34, inside back cover

Drafting pencil . . .

has knurled finger-grip for nonslip holding. Lightweight units have low-friction clutch mechanism to hold leads. Available with degree markings, fixed and adjustable for identification of leads. For color drafting, pushbutton lead holders have color-indicator tops. Leads come in 24 colors. Imported from West Germany. **J. S. Staedtler, Inc., Hackensack, N. J.**

Circle 35, inside back cover

Torque gage . . .

measures 2 to 40 in.-oz of torque clockwise and counterclockwise on servos, small motors and miniature rotating devices. Can be read directly on watch-face, linear-scale dial, which can be furnished

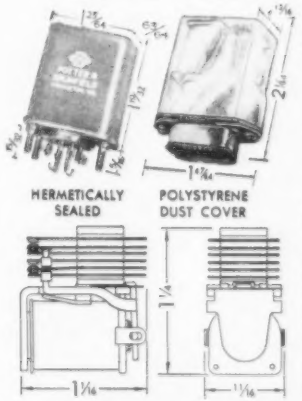
(Continued on page 119)

MINIATURE TELEPHONE TYPE RELAY HAS SUPERIOR SHOCK/VIBRATION RESISTANCE

Unusual for a telephone type relay, the MG Series has excellent stability under high shock and vibration conditions. Tests show this miniature, light weight (only 1.2 oz., open) relay withstands vibration of 10g 55 to 500 cycles per second and will operate under shock to 30g according to Mil-R-5757C.

The superior performance of the MG is due in part to its unique single stack construction and to an exclusive hinge design which provides zero heel gap.

Open, dust covered or hermetically sealed, the MG is available with contact arrangements up to 4 Form C (4PDT). It is rated for ambient temperatures of −55°C to +85°C. A high-temperature version with a range of −65°C to +125°C will soon be available. Write or wire today for complete specifications and delivery information.



MG RELAY

TERMINALS:
Open Relay: Pierced Solder Lugs.
Contacts: Two #18 AWG wires. Coil: Two #20 AWG wires.
Hermetically Sealed:
Miniature plug-in header with 7, 9 or 14 pins. Multiple Solder header with hook end terminals for three #20 AWG wires.
Polystyrene Dust Cover: Micro Ribbon plug-in type.
Mating receptacle: Amphenol #57-20140 or similar.
INSULATION RESISTANCE: 100 megohms min.
VIBRATION: .065" excursion 10-55 cps. 10g 55-550 cps. upon request.
SHOCK: 30g according to Mil-R-5757C upon request.
TEMPERATURE RANGE: −55°C to +85°C.
WEIGHT: 1.2 ozs. (open) 2.0 ozs. (sealed).
PULL-IN SPEED: Approximately 15 ms at nominal voltage.
DROP-OUT SPEED: Approximately 10 ms at nominal voltage.
CONTACTS: 3/32 silver.
CONTACT ARRANGEMENT: 4 pole, double throw (4 Form C).
COIL POWER: 3 watts max. DC @ 25°C. Continuous duty.

P&B STANDARD RELAYS ARE AVAILABLE AT YOUR LOCAL ELECTRONIC, ELECTRICAL AND REFRIGERATION DISTRIBUTORS

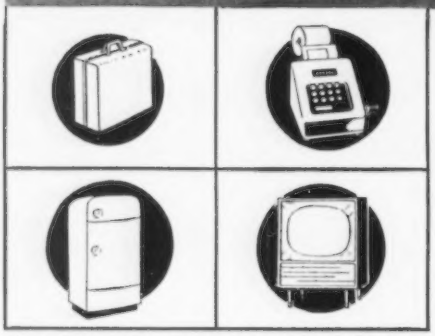
Potter & Brumfield, inc.

PRINCETON, INDIANA

SUBSIDIARY OF AMERICAN MACHINE & FOUNDRY COMPANY
Manufacturing Divisions also in Franklin, Ky. and Laconia, N. H.

NOW . . . A NEW FINISH

colorful, practical vinyl plastic for lamination to metal



- *Can be permanently laminated to metal . . . flat sheets or continuous coil.*
- *Can be crimped, shaped, bent or drilled without damage to textured finish.*
- *Won't chip, peel or fade.*
- *Resists abrasion.*
- *Easy to keep clean with soap and water.*
- *No special machinery required. Forming or stamping can be done on present equipment.*
- *Unlimited color and design selections.*

THE MASLAND DURALEATHER CO., Dept. PE
Amber and Willard Sts., Philadelphia 34, Pa.
Please send me samples of Masland Duran Clad:
NAME_____
COMPANY_____
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CITY_____ ZONE_____ STATE_____

A new and more functional finish for greater sales appeal. That's Masland Duran Clad, bringing the texture, warmth and color versatility of practical vinyl to countless products. Find out how your product can have this modern money-saving finish. Write for free folder.

Masland Duran®
CLAD
PLASTIC MATERIALS
vinyl sheeting

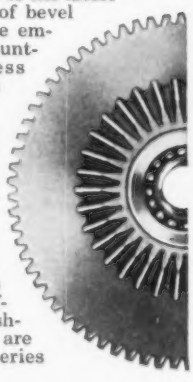
Industrial Products Division
THE MASLAND DURALEATHER CO.,
Dept. PE, Amber and Willard Streets, Philadelphia 34, Pa.

NOW YOU CAN TAKE ANOTHER LOOK AT

BEVEL GEARS

Designers can now re-consider the use of bevel gears—due to the latest Gleason coniflex system of bevel gear proportions which we employ—to minimize gear mounting problems and for less trouble after assembly. Costs are less by this method, better finishes and smoother gear operations are a result, and because bevel gears are so efficient, they can now be used more extensively than ever before.

We can make bevel gears up to 3" in diameter with up to 16 diametral pitch for such products as instruments, power tools, differentials, appliances, and fishing reels. Process bevel gears are precision engineered, deliveries are prompt.



Send blue prints or specs for prompt estimates to the specialists in the Fine Pitch Field.

PROCESS GEAR COMPANY
4602 W. Fullerton Ave. • Chicago 39, Ill.

109

Strataflo
ALL POSITION
CHECK VALVES
Sensitive Quiet

For steam, hot or cold water, oil, gas and compounds.

DESIGNED for rugged service. 200 pounds pressure. These valves can't stick. They are also available with rubber poppets for use with air or cold water. Operation is noiseless. Very sensitive. Work in any position. Made in seven sizes. We will design special Check Valves. Write today for Bulletin Number 201.

Order from your jobber.

write for FREE BULLETIN

STRATAFLO PRODUCTS, INC.
Fort Wayne, Indiana

calibrated in in.-oz or gm-cm. Standard accuracy is ±5% of full scale; ±1% at any point or ±2% of full range can be provided. Dimensions, 1⅝ x 3⅞ in. Weighs 7 oz. Keyless chuck is standard **Waters Mfg., Inc., Wayland, Mass.**

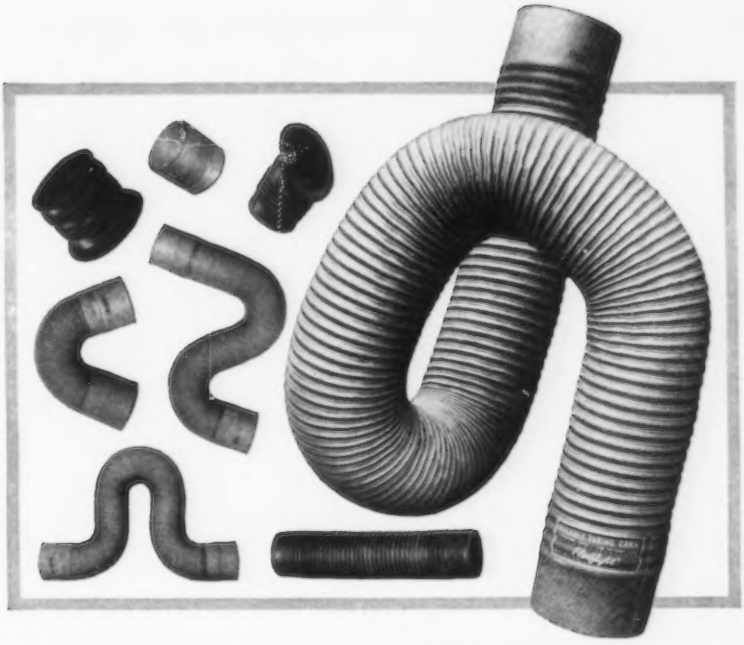
Circle 36, inside back cover

Printed circuit voltmeter . . .
has tilting meter that can be read from any angle. A switch automatically shorts or opens test leads for zero and infinite ohms adjustment. Meter reads peak-to-peak and rms voltages. Frequency range is up to 250 mc when used with No. 912 probe; voltage ranges up to 30,000 v with No. 999 HV probe. Available in kit or wired form. **Precise Development Corp., Oceanside, N. Y.**

Circle 37, inside back cover

Blueprint file . . .
has locking doors and is fitted with 112 tubes on a patented base that tilts to file and locate rolled maps, drawings, blueprints and tracings. Metal cabinet accommodates items to 60 in., located by a card file control. A top shelf provides storage for indexing card file and other office supplies. Available in various colors. **Scott-Rice Co., 610 S. Main St., Tulsa 3.**

Circle 38, inside back cover

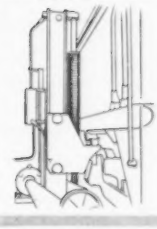


Here's why so many of today's specs call for FLEXIBLE TUBING products

Flexible Tubing has a thorough understanding of industry's ducting needs. Close collaboration with design engineers and trouble-shooting trips—hundreds and hundreds of them—have familiarized our engineers with countless ducting problems. Each successive job we've tackled has added to our knowledge of ducting behavior. And over the years we've acquired the facilities and equipment needed to meet any requirement. We now have completely integrated plants for development and production on both coasts.

Our present line of flexible ducting is the most complete, most diversified in the industry and we're always prepared to vary or modify any part of it. In the panel below we mention several recent applications for Flexflyte and Spiratube—lightweight ductings available with special fabrics and coatings for a wide range of temperature and pressure applications.

The background and experience of our field engineers are at your service. Let us know your requirements and we'll be glad to have one of them stop by to talk over your problems. For full information, write Dept. 252



Example

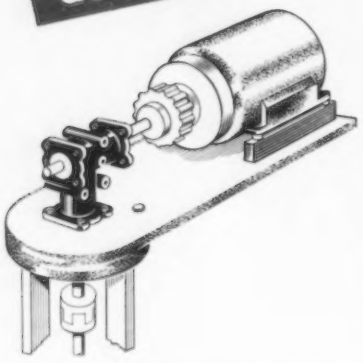
Spiratube used as protective covering on actuating screw of railroad car boot jack.

Other typical applications

Flexflyte: feeder tubes for gluing machines; organ piping connections; sander tubes for railroad cars; connector ducts from abrasive wheels to dust collectors on buffing and tire-truing machines.
Spiratube: crop drier hose; for dust collecting from multiple drill rig; for venting cooling air from diesel locomotives.

Flexible Tubing
CORPORATION
GUILFORD, CONNECTICUT
ANAHEIM, CALIFORNIA • HILLSIDE, ILLINOIS

ANGLgear® simplifies power package design



Drawing based on photo shows ANGLgear power takeoff on power package for liquid tar pump. ANGLgear's compactness and 4-way mounting simplified design of unit, helped reduce size.

In designing a power package for a portable tar pump used in roofing work, Continental Cleveland Corp., Cleveland, Ohio, needed a simple, compact 90° power takeoff to stand rough service and handle heavy transmission loads.

A Model R-340, 5 hp ANGLgear met these requirements perfectly. Because of its compactness and 4-way mounting feature, it was easily designed into the power train and helped reduce the size of the entire power unit. It also had the necessary stamina to absorb the loads involved in pumping liquid tar to heights up to 90 ft. Completely enclosed, it could not be fouled by the tar.

Perhaps ANGLgear can solve a 90° drive problem for you. Designed for manual or power operation, ANGLgears are available from stock in 1/3 to 5 hp ratings, with 2 or 3-way shafting, and 1:1 or 2:1 gearing.

See our literature in Sweet's Product Design File or contact your local distributor.

AIRBORNE®

AIRBORNE ACCESSORIES CORPORATION
HILLSIDE 5, NEW JERSEY

CATALOGS and BULLETINS

To obtain copies of literature described below, circle corresponding number on postcard inside back cover.

DC CONTACTORS AND RELAYS—Catalog GEA-6621, 32 pp. Covers general-purpose, mill-type and time-delay contactors, and general-purpose, timing, instantaneous-overload and thermal-overload relays; also field-loss, field accelerating and decelerating relays and high drop-out relays. Selection and application data is given with ordering instructions, product descriptions, photos of representative units and pertinent technical data. General Electric Co., Schenectady 5, N. Y.

Circle 39, inside back cover

FABRICATED RUBBER HYDRAULIC PACKINGS—Folder, 4 pp. Lists number of leather, homogeneous rubber and fabricated rubber V-packings that should be used under various operating pressures. Outlines the use of male and female adapters with V-sets. Lists standard V sizes. E. F. Houghton & Co., 303 W. Lehigh Ave., Philadelphia 33.

Circle 40, inside back cover

BRASS AND BRONZE ALLOYS—Booklet, 16 pp. Chemical, physical and mechanical properties and specs of brass products are given in tables. Information is listed for brass rod, wire, welding rods, hot-pressed forgings and pressure die castings. Customer Service Div., Titan Metal Mfg. Co., Bellefonte, Penna.

Circle 41, inside back cover

FLEXIBLE COUPLINGS – Bulletin 101000, 8 pp. Tells how to select couplings for more than 150 service applications. Five tables of short-cut engineering calculations. T. B. Wood's Son's Co., Chambersburg, Penna.

Circle 42, inside back cover

GLASS-SUPPORTED TEFLON – Brochure GST-58, 8 pp. Gives mechanical, electrical and chemical properties of glass-supported Teflon sheets, tapes, laminates, metal-clads and fabricated parts. Process is briefly outlined. Also, widths, nominal thicknesses and thickness tolerances for standard and special grades of materials and components. Continental-Diamond Fibre Corp., Sub. of Budd Co., Newark 107, Del.

Circle 43, inside back cover

SNAP-ACTING SWITCH TERMINOLOGY—Folder, 4 pp. Standard definitions for snap-acting switches adopted by NEMA are listed with illustrations. An exploded view of a typical switch identifies basic parts and general construction of switches. Drawings of operating cycle illustrate the NEMA definitions. Several of the firm's line of switches are illustrated on one page. Hetherington, Inc., Folcroft, Penna.

Circle 44, inside back cover

SWITCHES—Data sheets 141 and 142, 4 pp. each. Sheet 141 describes series of rocker-actuated switches with photos, dimensional drawings of one, two and four-pole types; electrical data and operating characteristics. Sheet 142 describes pull-to-unlock toggle switches, with photos and dimensional drawings of one, two and four-pole types. Also, drawings show 11 locking designs and charts of electrical data. Micro Switch, Div. of Minneapolis-Honeywell Regulator Co., Freeport, Ill.

Circle 45, inside back cover

HIGH-STRENGTH STEEL—Booklet, 24 pp. Engineering booklet on steel made by the patented elevated-temperature drawing process. Gives results of tests, reports on eight applications and provides engineering specs of basic bar and ground and polished product. La Salle Steel Co., 1420 150th St., Hammond, Ind.

Circle 46, inside back cover

CONED DISK SPRINGS—Brochure, 16 pp. Formulas and design information on the springs illustrated with dimensional drawings. Various end uses are shown. Union Spring and Mfg. Co., New Kensington, Penna.

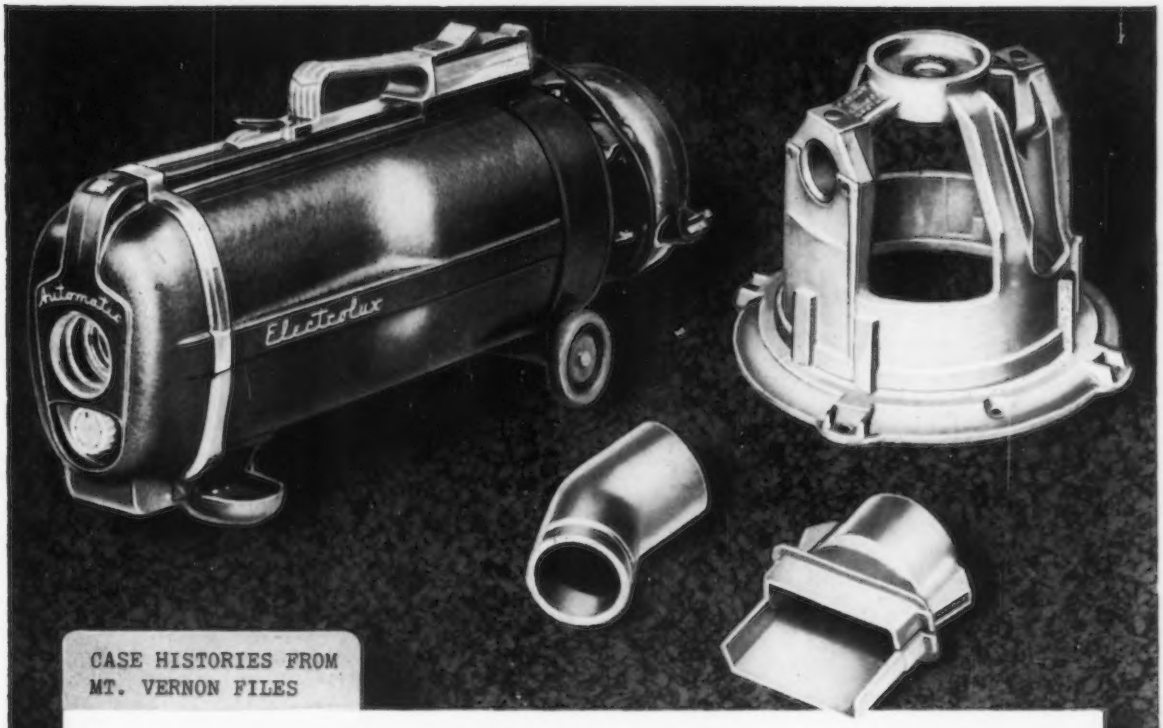
Circle 47, inside back cover

CONTROLS—Bulletin J-101, 8 pp. Describes shaft-mounted positioning gear-motors for valves, drives, pumps and other applications. Specs for a new system for machine tool positioning and for process control are also presented. With photos and diagrams. Jordan Co., Inc., 3235 W. Hampton Ave., Milwaukee 9.

Circle 48, inside back cover

SINGLE COMPONENT BOND—Bulletin 114, 2 pp. Characteristics and properties of a single component epoxy preform used in automatic or high-production joining of metals, plastics, ceramics and glasses. Includes listing of typical applica-

(Continued on page 123)



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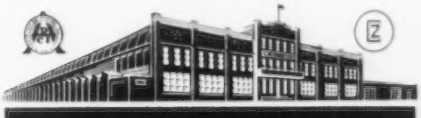
The minute this new Automatic Electrolux Cleaner has absorbed so much dirt it can no longer operate at high efficiency, it stops and the cover pops open. Replacing the sealed paper dust bag with a new one sets it up for further operation. It is one of several exclusive Electrolux features which includes 20% greater suction power than any machine the company has ever made. This is due in part to the increased speed and power of its electric motor.

The additional power and the automatic features of this new cleaner were not, however, achieved at the expense of added weight, because it is remarkably light for an appliance of such power and flexibility. By using die castings for the motor frame, elbow and adapter, both weight and manufacturing costs were kept down. As you can see these parts are complex. The motor frame alone, for example, involves apertures of various sizes and shapes, lugs, curved members, straight members, flanges, fillets, vanes and shoulders all combined into a very lightweight yet extremely rigid, strong unit. The other parts, although smaller, are also "toughies". But die casting is the most economical method of producing these intricate parts which combine strength with light weight and holding to such close tolerances that little or no machining is reqiured to finish them.

Mt. Vernon can help you make the most of these and other die casting advantages by a complete four-fold service of: (a) consultation—to help with design and production problems; (b) die making—on modern tool and die equipment handled by skilled personnel; (c) castings—aluminum and zinc, guaranteed "on grade" at all times; (d) machining facilities—for handling any machining operations your castings may require. As in the case of Electrolux, a switch to die castings may profit you tremendously. Let's talk it over.



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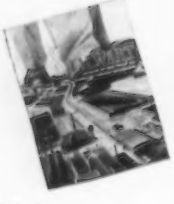

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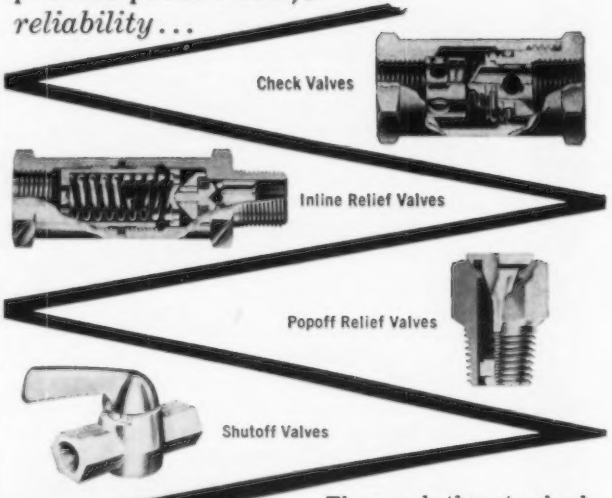

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See Our Catalog in Sweet's Product Design File

tions and photo. Duramic Products Div., Technion Design & Mfg. Co., Inc., 262-72 Mott St., New York 12.

Circle 49, inside back cover

RIGID LAMINATED PLASTICS—Brochure, 18 pp. Characteristics, properties and fabrication of various thermosetting laminated plastics are discussed. Mica Insulator Co., Schenectady 1, N. Y.

Circle 50, inside back cover

SYNCHRONOUS MOTOR — Bulletin PB-117, 2 pp. Offers technical, operational and design data of the permanent-magnet synchronous motor. Specs on all five versions, including torque ratings, speeds, shaft dimensions, are presented in addition to material and construction information. Cramer Controls Corp., Centerbrook, Conn.

Circle 51, inside back cover

PRESSURE REDUCING VALVES—Bulletin J-160, 6 pp. Gives information on sliding-gate pressure-reducing valves. Describes features, design improvements and method of operation. Contains flow capacity charts, dimensional drawings, control ranges and material specs. Jordan Industrial Sales Div., OPW Corp., 6013 Wiehe Rd., Cincinnati 13.

Circle 52, inside back cover

SOLENOIDS, COILS, ELECTRONIC COMPONENTS—Catalog, 10 pp. Describes and illustrates line. Includes specifications, charts and graphs. Anderson Controls, Inc., 2777 Manheim Rd., Des Plaines, Ill.

Circle 53, inside back cover

ADJUSTABLE SPEED DRIVE—Bulletin 2000, 12 pp. Discusses applications, with illustrations, of unit available from 5 to 200 hp. Stresses ease of installation, optional features for special applications. Includes performance data and dimensional information. Louis Allis Co., 427 E. Stewart St., Milwaukee 1.

Circle 54, inside back cover

INDUSTRIAL AND INSTITUTIONAL CASTERS—Catalog, 165 pp. Describes some 10,000 industrial and institutional casters and 500 types of handling equipment. Products are classified and identified by a color code. Colson Corp., Sub. of Great American Industries, Inc., Elyria, Ohio.

Circle 55, inside back cover

INDUSTRIAL THERMOMETERS — Catalog 125A, 24 pp. Contains engineering data on units, including case and socket dimensions, standard temperature ranges and scale divisions. Weksler Thermometer Corp., 195 E. Merrick Rd., Freeport, N. Y.

Circle 56, inside back cover

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In Horsburgh & Scott's new Gear Catalog No. 57 you get *all* the information necessary to design and order the gearing offering greatest efficiency and operating economy for your industrial applications.

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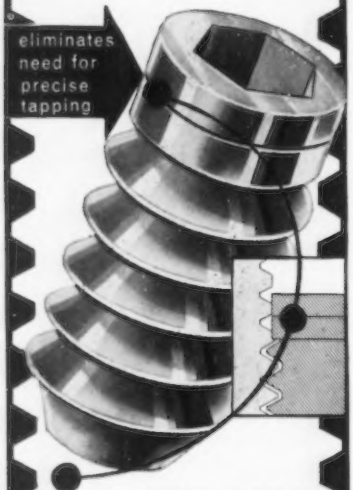

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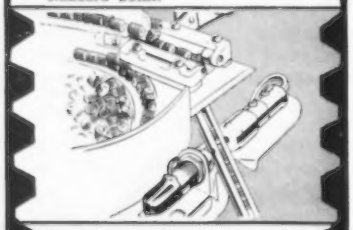

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DESIGN ABSTRACTS

Lubrication Standards for Industrial Equipment

With no standards to follow, equipment manufacturers have created a situation where different lubricating devices and systems, methods of applications, and an unnecessary multiplicity of lubricating materials and schedules have been imposed on many plants. For example, commonly used grease fittings are available in five types, three thread sizes and five drive sizes. Threads and drive fittings sometimes vary on same machine.

Author's company instituted its own lubrication standards program in 1955. Indicative of the approach taken are the standards proposed for safety: (1) lubricating devices may not be mounted on moving machine elements; (2) flexible lines must be restrained or confined; (3) personnel must not be required to reach past moving elements or equipment.

Among other lubrication considerations included: servicing should be possible during operation; lubricant cleanliness must be protected; engineered central lubricating systems are encouraged and discussed; accessibility of lubricating points; national pipe-thread sizes must be specified.

Abstracted from "Lubrication Standards for Industrial Equipment," by S. O. Kimball, AC Spark Plug Div., General Motors Corp., Lubrication Engineering, Dec. 1957, 84 E. Randolph St., Chicago 1.

Development by Calculation or Test?

This article is concerned with the point at which analysis of product development problems should stop and testing should take over. The authors propose that those design approaches that permit prior calculation should be adopted whenever possible, pointing out the higher costs of relying on testing procedures at stages that are too early.

Testing is advisable at certain stages of product development, and can often be profitably and inexpensively applied to components and subassemblies. Examples of engineering problems solved by analysis are given. The possibility of a cost-accounting system to develop comparative cost figures between analysis and testing is considered.

Abstracted from "Engineering Development —by Calculations or Test?," by R. Ravenhall, J. E. Fee, G. W. Bishop, Bishop Engineering Co., Environmental Quarterly, Fourth Quarter, 1957, 9 Spring St., Princeton, N. J.

Selection of Glass Reinforcement for Plastics

The type and form of glass reinforcement in structural plastics is of decisive importance in determining properties, including strength, rigidity, moldability, size limits, directional characteristics, cost, and production methods. Available types, sizes and forms of basic glass fibers are described, as well as how they differ from bulk glass. Manufacture of glass fiber is briefly recounted, and importance of surface characteristics in achieving good bonds with plastic compounds is described.

Forms in which reinforcement are available are individually discussed: mats, rovings, chopped strands, milled fibers, yarns, and woven fabrics. Economic considerations of each of these materials is also included.

Abstracted from "Glass Reinforcement for Structural Plastics," by R. G. Adams and R. Sonneborn, Owens Corning Fiberglas Corp., SPE Journal, Dec. 1957, Security Bank Building, Athens, Ohio

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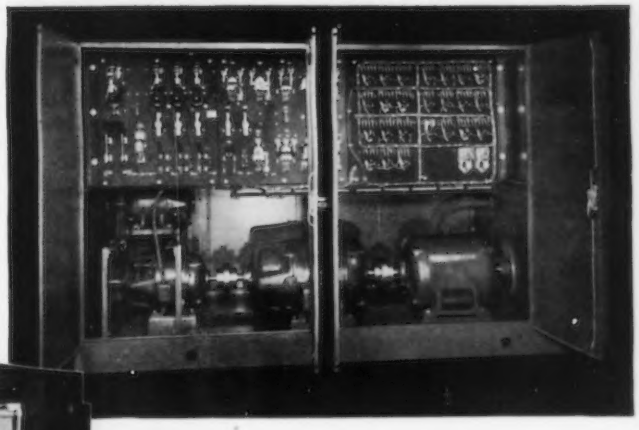

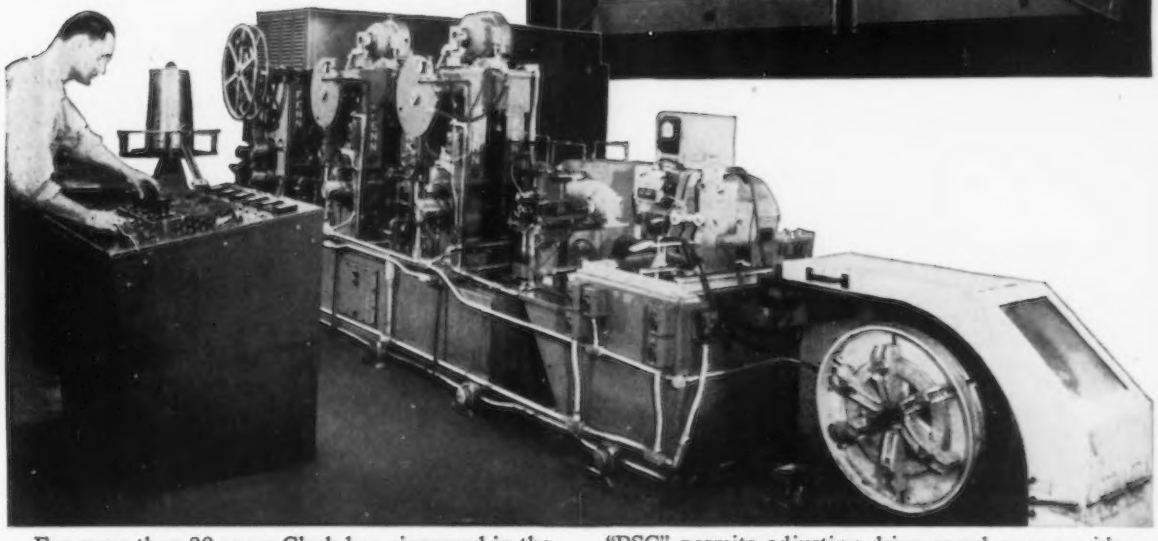

For more than 20 years Clark has pioneered in the field of adjustable voltage DC control systems. Since 1934, our company has been a major supplier of specially engineered control for processing lines in the basic metals, rubber and plastics industries, where the advantages of adjustable voltage DC systems have long been recognized.

Now Clark "PSC" (Packaged Speed Control) incorporating the knowledge and experience gained by Clark engineers over the years, is available in compact, factory-assembled units in attractive pressure ventilated cabinets that fully protect the equipment and occupy a minimum of plant floor space. "PSC" Drives include the conversion equipment for changing AC to DC, panel mounted control equipment and separately mounted pilot devices, as well as DC drive motors.

Clark will either supply the drive motors, recommend proper motors, or design the "PSC" for motors owned or supplied by the customer.

"PSC" permits adjusting drive speed over a wide range by controlling motor armature voltage and/or field current. Modifications may be incorporated to adapt "PSC" to an almost limitless variety of applications where controlled-speed DC drives are advantageous.

Illustration shows a modern 3-stand tandem wire flattening mill with the individual stand drives synchronized electrically by Clark "PSC". Compared to similar machines in the same plant with mechanical synchronization, this mill is five times faster with more precise speed and tension control. Thus it holds closer tolerances and reduces breakage of light material.

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NEW BOOKS

Research on Heat-resistant Structural Adhesives

H. G. LeFort, R. M. Spriggs, D. G. Bennet, *U. of Illinois Report to WADC, PB 121941. Available from Office of Technical Services, US Dept of Commerce, Washington, D. C. Paperbound,* 8½x11, 65 *pp.* $2.

This report covers a recent investigation into ceramic adhesives for Type 301, 302, and 17-7PH stainless steels, including adhesives based on ceramic oxides, glass-bonded coatings, cermets with sintered metal bonds, air-setting temperature-resistant silicates, aluminates, oxychlorides, oxysulfides, and ceramic-oxide resin-bonded coatings. Several of these experimental adhesives were used to successfully bond small Type 17-7PH honeycomb sandwich panels.

As a result of this research, adhesives were developed that cover following shear strengths and temperatures, though no single adhesive covered all conditions: 1200 psi at room temperature, 1100 psi at 600 F, 2300 psi at 900 F and 800 psi at 1000 F. Attempts to improve shear performance by specially preparing the metal surface—knurling, scouring, chemically pickling and etching—did not substantially improve results. Use of 120-mesh stainless screen as carrier for the adhesive increased average shear strength of the best ceramic adhesive developed. It was also found that superior shear strengths resulted when thermal coefficient was adjusted to more closely match base-metal coefficient by addition of oxides of the alloys in the base metal.

Epoxy Resins: Their Applications and Technology

Henry Lee, *Technical Director, and* Kris Neville, *Project Director, Epoxylite Corp. Published by McGraw-Hill Book Co., Inc.,* 330 W. 42nd St., New York 36. 6x9, 305 *pp.* $8.

This book is a comprehensive guide to the new field of epoxy resins. It ranges from detailed chemistry to practical applications. Available data and

(Continued on page 127)

more information about . . . metals and alloys

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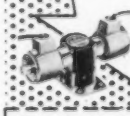

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information are presented on their synthesis and curing mechanisms, curing agents, and various materials used as fillers and modifier. Emphasis is on engineering versatility, range, and potentialities of the epoxies in product design.

The book discusses industrial applications for the various epoxy resin systems in laminates, adhesives, coatings, castings, pottings, foams and so on. Handling characteristics are considered in detail, as are methods for characterizing both cured and uncured resins.

Provided are full and complete answers to such questions as: how do these new materials work, what are their strong and weak points, how can they be best used for a specific application.

Some recent articles in PRODUCT ENGINEERING covering aspects of epoxy resins in detail include the following: "Core Materials for Sandwich Panel Construction," Jan. 20, '58, includes information in epoxy foams; "Pre-painted Steel," Dec 9, '57, discusses epoxy finishes for this economical metal form; "Epoxy Castings," June '57, shows how to design large cast parts as a low-cost alternative to metal or molded plastics; "Single-Component Epoxy Adhesive," May '57, presents data on a nonrunning high-strength adhesive for elevated temperatures.

Technical-report Writing

JAMES W. SOUTHER. *Published by John Wiley & Sons, Inc., 440 Fourth Ave., New York 16. Paperbound, 8¼x10¾, 70 pp. $2.95.*

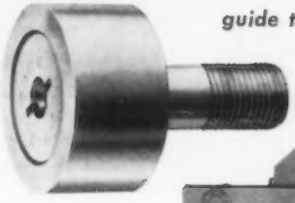
"The ability to write effective reports is one of the most valuable skills that a professional engineer or scientist can develop, for his own career may well depend on it." Yet despite the growing importance of effective communication few professionals make any attempt to study the subject with the attention it deserves —probably because anyone who has learned to read and write is convinced he does so with skill.

This book will serve equally well as a college text or a do-it-yourself primer on report writing. The author approaches the subject with the same attitude used to solve a mechanical-

(Continued on page 129)

SMITH CAM FOLLOWERS

guide the Saw Table on this Short Log Saw with "repair parts practically nil" says J. W. PENNEY & SONS CO.



Standard Interchangeable

The "JWP" Short Log Saw equipped with SMITH Standard Cam Followers

J. W. Penney & Sons Co. of Mechanic Falls, Maine, use eight of these SMITH long-life, anti-friction Cam Followers to guide the table on each of the standard machines shown here. These machines are used for sawing boards or blocks and planks, which are then resawed for further processing in the woodworking industry.

In upper left corner is shown the type of SMITH Cam Follower used in this machine. The flange that holds the roller is a part of the stud itself, resulting in greater strength and long life. Maintenance and replacement costs are greatly reduced. For special applications the STUD DIAMETER can be made up to 100% greater in relation to the size of the roller.

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Bulletin Lists Names and Addresses of All Distributors

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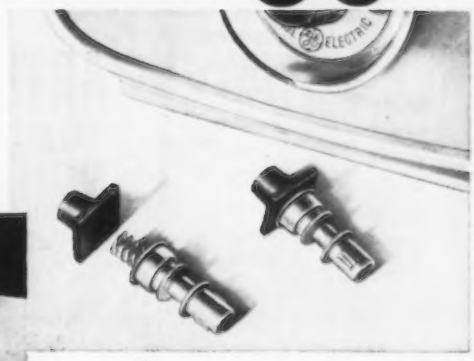

Exclusive Gries techniques actually improved design and performance by die casting this zinc alloy threaded shaft and injection molding the mating Nylon nut. Both units formerly were produced as screw machine parts, at 5 times the present cost. A typical demonstration of GRC's unique talent for doing big things with small parts . . . *economically!*

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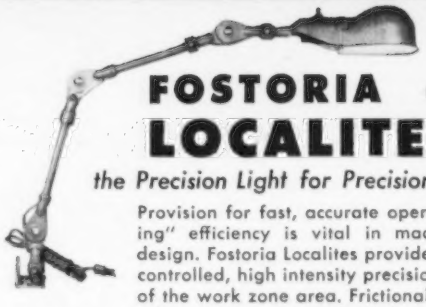

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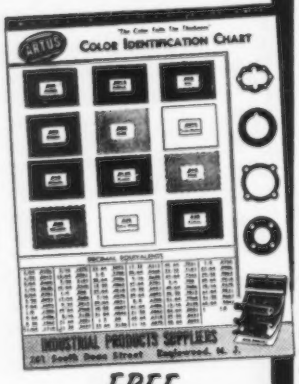

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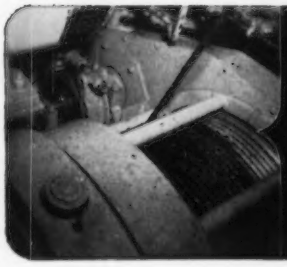

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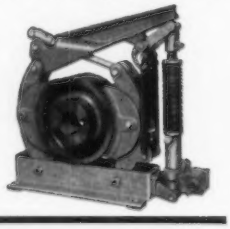

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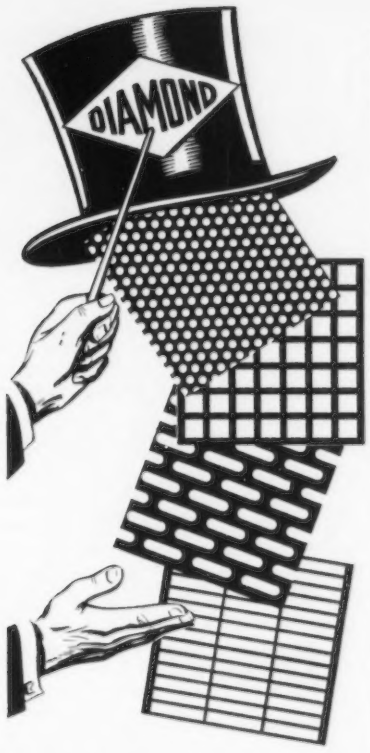

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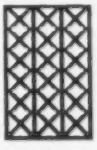

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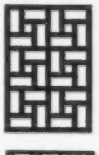
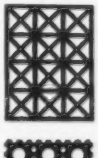


Correspondence is especially invited regarding ANY requirement for perforated-metal panels or parts. We are equipped to fabricate special sections to any desired extent and welcome opportunities to make money-saving suggestions.



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Basic Research— A National Resource

Published by National Science Foundation. Available from Superintendent of Documents, US Government Printing Office, Washington 25, D. C. 10½x7½, 64 pp. $0.45.

In addition to providing a statistical and descriptive analysis of the basic research effort of the United States, the report suggests ways to encourage research in science. These include increased support for university research that conforms to the educational and scholarly programs at the school involved, with reduction of support for enterprises unsuitable for the university; a redefinition of the rules under which tax-exemption

(Continued on page 131)

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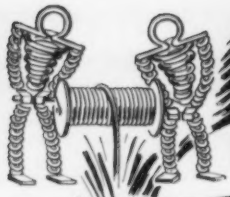

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Introduction to Work Study

Published by International Labor Office, Washington Branch, 917-15th St., N.W. Washington 5, D.C. 10x6¼, 349 *pp.* $3.50.

This book was written partly for persons attending courses in work study run by International Labor Office technical-assistance missions, and partly to help provide lecture material for the missions themselves and the staffs of national productivity centers in countries receiving ILO technical assistance. Its four parts are: Productivity and work study, method study, work measurement, appendices.

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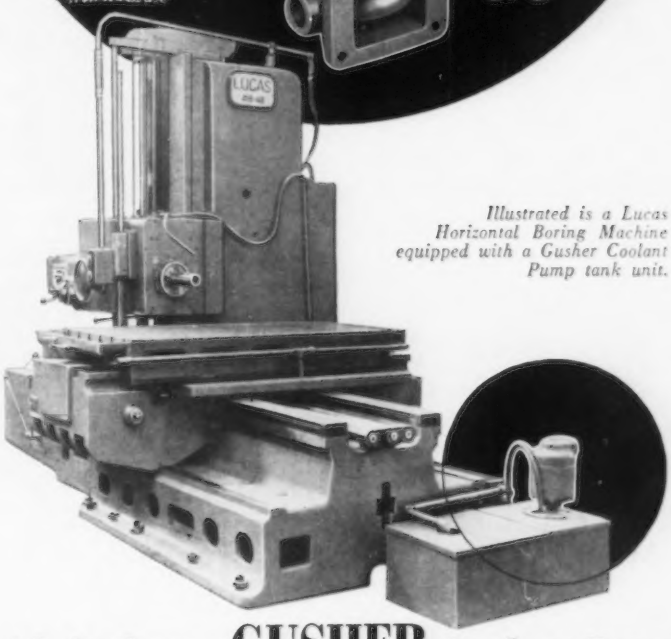

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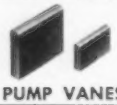
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SK 145	90	8000	1.80	800	
SK 187	80	9000	1.79	650	High Altitude Bearings
SK 188	65	7000	1.78	650	
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SK 154	100	10000	1.75	650	
SK 157	75	7000	1.80	250	Appliance Seals
SK 176	80	7000	1.80	650	
SK 105	75	7000	1.60	500	Oil Seals
SK 175	75	7000	1.75	500	
304	80	9000	1.79	650	Vanes & Bearings
331	50	7000	1.74	800	Turbine Rings
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Y20	40	3000	1.65	650	
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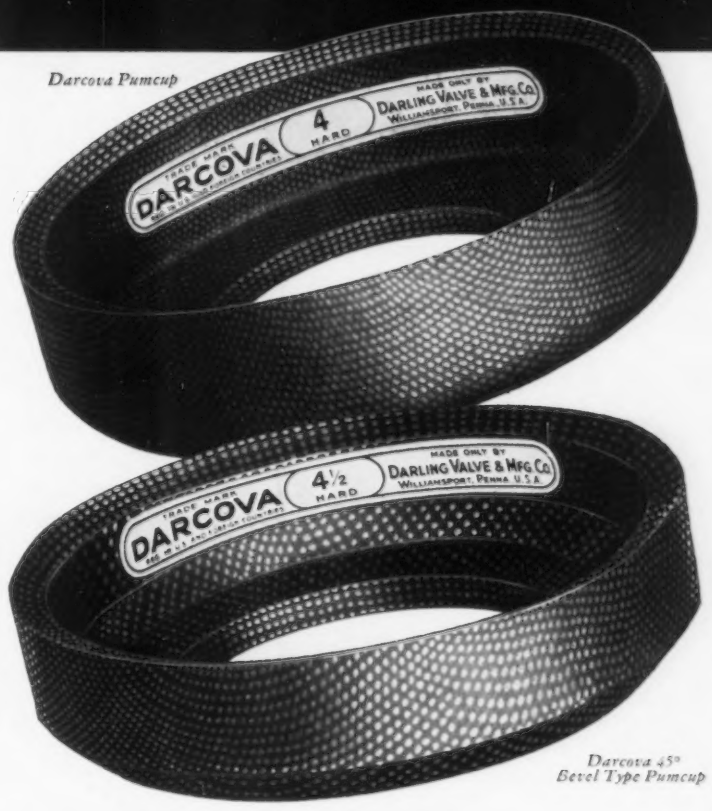

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San Francisco 4 . . . W. C. Woolston, 68 Post St., Douglas 2-4600

CLASSIFIED ADVERTISING
F. J. Eberle, Business Mgr.

EMPLOYMENT OPPORTUNITIES 134

Index to Advertisers begins on P. 135
Products Index begins on P. 132

MORE EFFICIENT DESIGN, IMPORTANT SAVINGS, SIMPLIFIED ASSEMBLY, BETTER APPEARANCE

These are some of the many benefits reported by Design Engineers who have adopted TRU-LAY PUSH-PULLS for remote control operations on literally hundreds of products

Here are typical comments recently received from equipment manufacturers whose machines or implements are equipped with these accurate and dependable remote controls:

Saves Time, Labor and Material
"The use of your flexible Push-Pulls saves us a great deal of time, labor and material. The old linkages frequently required much planning in both engineering and shop which is not required now. On some of our equipment we use Push-Pulls from 10 to 30 feet in length. They operate clutch controls on the Main Power Unit, Feed Conveyors and Delivery Conveyors."

Greater Flexibility of Design
"The principal advantage of Tru-Lay Push-Pulls in our application is that they permit flexibility in locating the control valve in relation to the operator's position."

Cost Less to Install
"Tru-Lay Push-Pulls are easier and less expensive to install than linkages for remote control of power take-off, brake and clutch. Better appearance, too."

Simple and Neat
"For several models of farm tractors, we selected your controls for their simplicity and neatness of application as governor controls."

Solution to Tough Problem
"Can be installed where straight rods are impossible . . . for Remote Control of transmissions, brakes and clutches."

Eliminates Maintenance
"Simple operation and elimination of maintenance problem are the major advantages in using your Push-Pulls."

Reduces Number of Parts
"Your Push-Pulls have eliminated links, radius rods and other lost-motion devices for remote control of hydraulic valves."

Provide ACCURATE Control
"Tru-Lay Push-Pull control cables provide minimum back-lash, even in installations up to 30 feet in length, because the cable is designed to close tolerances with minimum drag and lost motion."

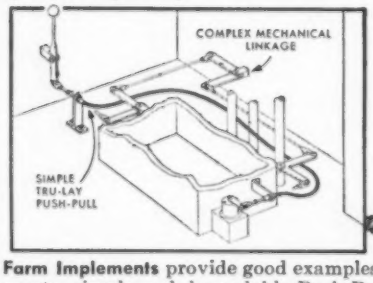
• • •

TRU-LAY PUSH-PULLS are "Solid as a rod but *Flexible* as a wire rope." This flexibility makes it possible to snake around obstructions . . . permits the ideal arrangement of all elements of remote controls.

Advantages *of Tru-Lay Push-Pull flexibility and simplicity are pictured below—*

Simplicity vs Complexity

Compare the TRU-LAY PUSH-PULL cable in illustration with the mechanical linkage. PUSH-PULLS are simple, have but one moving part, are noiseless and give lifetime service accuracy. Linkages are complex, made of many parts; they wear at many points. Their use brings increased backlash, lost accuracy and vibration rattles.



Construction Equipment and **Farm Implements** provide good examples of the wide-spread use of these accurate, simple and dependable Push-Pulls. On Power Shovels, Winches, Graders, Road Oilers, Dump Trucks, Snow Plows, Engine-driven Pumps, Crushers, Tractors, Combines, Corn Pickers, Corn Row Sprayers, Corn Detasslers, Orchard Sprayers, Power-driven Tree Trimmers, Tobacco Picking Machines and others . . .

TRU-LAY PUSH-PULLS are operating unfailingly for the remote control of Hydraulic and Air Valves, Brakes, Clutches, Transmissions, Throttles, Chokes, Governors, Power Take-Offs, Spray Nozzles, Vent Directional Fins and on many other applications.

Push-Pull DATA FILE

ACCO *Our DATA FILE will answer all further questions*

AUTOMOTIVE and AIRCRAFT DIVISION
AMERICAN CHAIN & CABLE

601-E Stephenson Bldg., Detroit 2
2216-E South Garfield Ave., Los Angeles 22 • 929-E Connecticut Ave., Bridgeport 2, Conn.

There is No Worry about Failures or Maintenance Costs with TRU-LAY Push-Pull Remote Controls

Long Life is a matter of record. We have never heard of a Tru-Lay Flexible Push-Pull Control wearing out in normal service. Failures, that sometimes harass users of more complex controls, are eliminated by the use of these simple, positive-action controls.

Dependable Operation of these controls is a certainty, even under the most adverse conditions . . . HOT as jet engines (note: Tru-Lay Push-Pulls are actually performing on hot jet applications) . . . COLD to 70° F below zero . . . SOAKIN' WET . . . ABRASIVE . . . or just plain TOUGH.

Freedom from Trouble is assured because of such features as . . . full protection of the inner, working member by the tough flexible conduit . . . lubrication of the inner, working member *for life* during assembly . . . seals that keep moisture, dust and other foreign matter out of the unit . . . cold swaging of fittings that makes them integral parts of the control unit.

Accuracy is inherent in the basic design of Tru-Lay Push-Pulls. They are precision products, not gadgets.

Capacity ranges from light jobs up to jobs of 1,000 lbs. input. These Push-Pulls will handle jobs 150 feet or more from the control point.

"Solid as a rod, Flexible as a wire rope" aptly describes Tru-Lay Push-Pull Controls. This flexibility provides positive, remote action whether anchorages are fixed or movable . . . it damps out noise and vibration . . . it greatly simplifies installation of controls by reducing the number of working parts and by making it possible to snake around obstructions.

Adaptability to all sorts of mechanical situations explains, in large measure, the wide-spread application of Tru-Lay Push-Pulls. Standard anchorages, fittings and heads have been designed that meet requirements on approximately 80% of the installations. Simple modifications of these standards, or minor changes in your own design, cover almost every special situation. Our engineers have the know-how on such matters, and will work with you.

For Further Information—The DATA FILE pictured at the left contains six booklets and bulletins that will answer any further questions you may have about this versatile and dependable tool. It is quite likely that this material will point the way to a simplified solution of your remote control design problems. Write for a copy.

More Details?

about

- **products advertised**
- **new components and materials**
- **new catalogs and bulletins**

Just send in post-paid card below, we'll do the rest

Now, one of these handy prepaid postcards will bring you more information about any product advertised or mentioned editorially in this issue of *Product Engineering*.

Here's How to Use the Card

For your copy of any new catalog or bulletin, circle key numbers in the space indicated. Bulletins are described on pages 120-123.

To get more data about new Components, Materials and Parts fully described on pages 85-119, just circle the appropriate key number.

To get more information about advertised products, circle the page number of the advertisement in which you are interested. If more than one advertisement is located on a single page, letters preceding number identify each advertisement. Key: T—Top; B—Bottom; R—Right; L—Left; TL—Top left; BL—Bottom left; TR—Top right; BR—Bottom right.

For specialized data . . . prices, sizes available, nearest source of supply, etc. . . . do not circle key number but indicate your needs in the space allotted at the bottom of the card. Use this space, too, if information about a specific product among several mentioned in an advertisement is desired.

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NEW COMPONENTS AND MATERIALS . . .

Description of these new engineering materials appear on pages 85-119. Circle key number for more data

1—Digital Counter Has Straight-line Readout
2—Diaphragm Pump Delivers Oil-free Air
3—Liquid Level Control
4—Coupling for Zero Adjustment
5—DC Rotary Torque Solenoids
6—Small Reset Counter
7—Motor-speed Control Package
8—Bypass Valve
9—Rechargeable Batteries
10—Servo Motor Gearhead
11—Air and Hydraulic Cylinders
12—Air Brake Attachment
13—Standard Load Switch
14—Explosionproof Transformers
15—Hanger Bearing Assemblies
16—Electrical Selector Switch
17—Series Attachment Plug
18—Transfer Valve
19—Miniature Clinch Nuts
20—Nylon Plate
21—S-section Sheave
22—Teflon High-pressure Hose
23—Multiple-station Manifolds
24—Continuous-duty Motors
25—Explosionproof Motors
26—Vacuum O-ring Fitting
27—Resilient Fan Hub
28—Beryllium Copper Spring Pins
29—Silicon Rectifier Power Supply
30—Variable Transformer
31—Manual Starters
32—Solenoid Valve
33—Rotary Vane Compressors
34—Rotary Pump
35—Drafting Pencil
36—Torque Gage
37—Printed Circuit Voltmeter
38—Blueprint File

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14-5	16	25	26	27	28	29	30-1	32	33
34	35	36	37	38-9	40	41	42	43-4	46
48	77	80	82	84	87	89	90	91	92-3
94	95	96-7	98	99	L100	R100-1	102	103	104
105	L106	R106	107	108	109	110	111	L112	R112
113	114	115	L116	TR116	BR116	117	T118	BL118	BR118
119	120	121	L122	TR122	BR122	123	124	125	L126
BR126	T127	B127	TL128	BL128	TR128	BR128	L129	R129	TL130
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41—Brass and Bronze Alloys, 16 pp. Titan Metal Mfg. Co.

42—Flexible Couplings, 8 pp. T. B. Wood's Son's Co.

43—Glass-supported Teflon, 8 pp. Budd Co.

44—Snap-acting Switch Terminology, 4 pp. Hetherington Inc.

45—Switches, 4 pp. Minneapolis-Honeywell Regulator Co.

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48—Controls, 8 pp. Jordan Co.

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50—Rigid Laminated Plastics, 18 pp. Mica Insulator Co.

51—Synchronous Motor, 2 pp. Cramer Controls Corp.

52—Pressure Reducing Valves, 6 pp. OFW Corp.

53—Solenoids, Coils, Electronic Components, 10 pp. Anderson Controls

54—Adjustable Speed Drive, 12 pp. Louis Allis Co.

55—Industrial, Institutional Casters, 165 pp. Great American Industries

56—Industrial Thermometers, 24 pp. Weksler Thermometer Corp.

PRODUCTS ADVERTISED

NEW PRODUCTS . . .

NEW BULLETINS . . .

SPECIFIC DATA . . .

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C2	1	4	L6	R6	8	9	10-1	12	13
14-5	16	25	26	27	28	29	30-1	32	33
34	35	36	37	38-9	40	41	42	43-4	46
48	77	80	82	84	87	89	90	91	92-3
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113	114	115	L116	TR116	BR116	117	T118	BL118	BR118
119	120	121	L122	TR122	BR122	123	124	125	L126
BR126	T127	B127	TL128	BL128	TR128	BR128	L129	R129	TL130
BL130	TR130	BR130	131	132	133	134	136	C3	C4

NEW COMPONENTS AND MATERIALS

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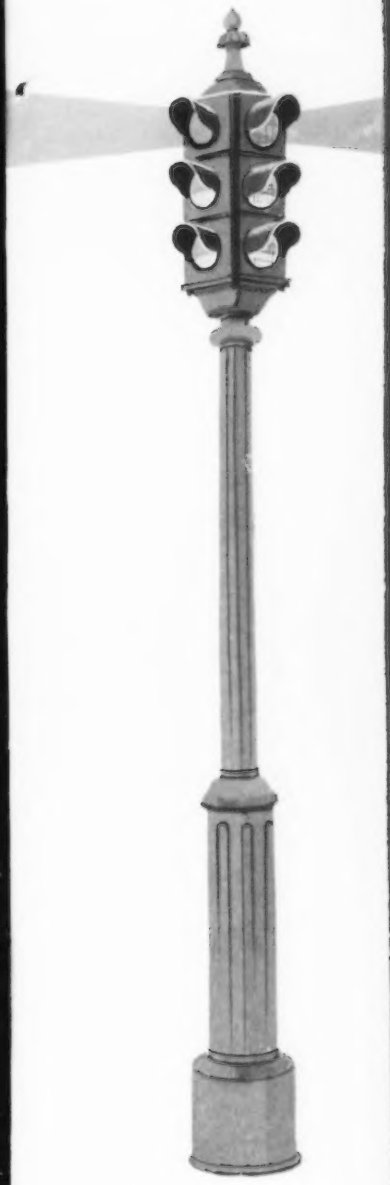
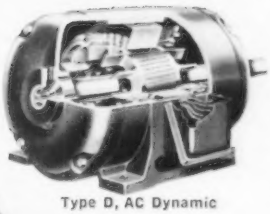


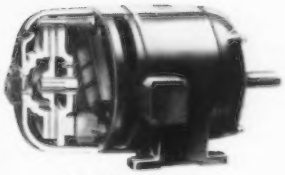
GIVE YOUR PRODUCTS THE BEST OF BRAKES!



Type D, AC Dynamic

ROLLING STOP... Master Type D Dynamic Unibrake Motors. Braking is obtained with a unique, patented brake winding superimposed on the stator winding. Simple, compact, with no DC current required, the brake has no moving parts. There is nothing to wear or adjust... braking torque repeats consistently. Particularly recommended for automatic applications where static holding is not desired. Sizes ¼ to 30 H.P.

MASTER UNIBRAKE MOTORS



Type M—Magnetic

STOP-HOLD... Master Type M Magnetic Unibrake Motors. For quick, controlled stopping... especially when you want to hold the load. Spring-setting magnetic brakes of the friction disc type combine with motor in a compact, integral unit. Sizes... ⅛ to 150 H.P.

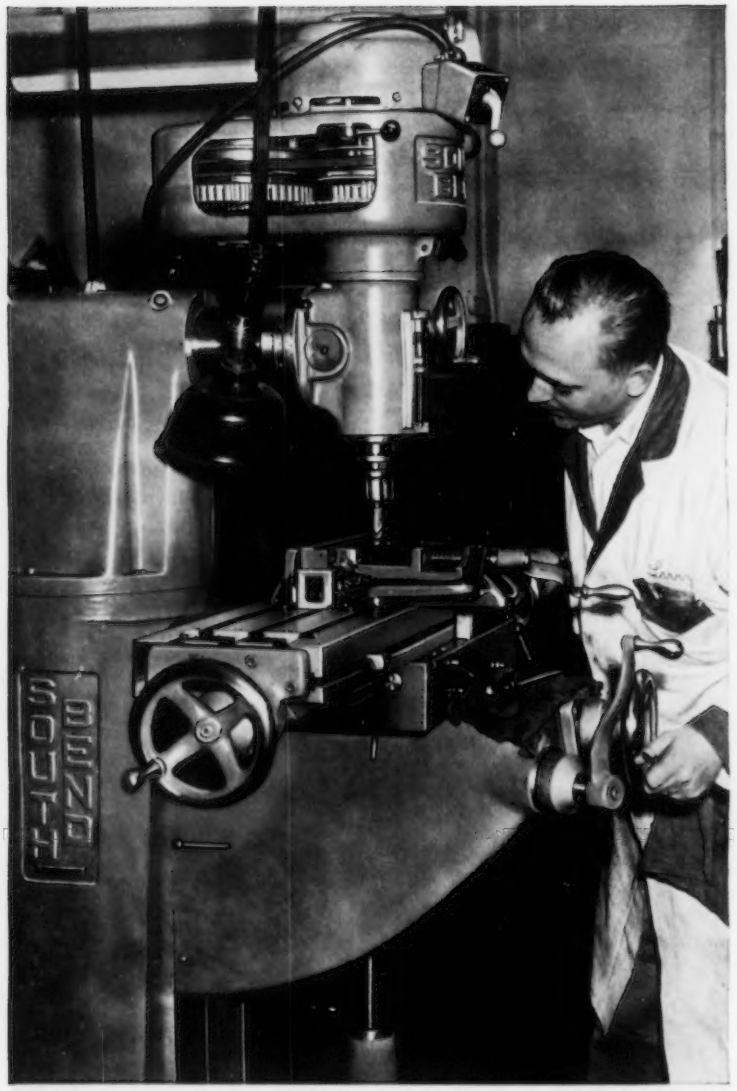
MASTER GEARMOTORS and variable speed drives can be furnished with Unibrakes, too. See Master for the perfect power drive for you.

THE MASTER ELECTRIC CO.

DAYTON 1, OHIO

DIVISION OF RELIANCE ELECTRIC AND ENGINEERING CO.

Precision milling machine spindle gets extra precision with TIMKEN® bearings



SOUTH BEND LATHE WORKS mounts the adjustable spindle of their vertical precision milling machine on two Timken tapered roller bearings to give it extra accuracy in any position. They also use Timken bearings in the elevating screw mechanism.

AT all eight speeds and at any angle, this vertical milling machine mills, drills and bores to fine tolerances. And to give the spindle extra precision in every position, South Bend Lathe Works mounts it on two Timken® tapered roller bearings. These Timken bearings:

HOLD THE SPINDLE RIGID AT ANY ANGLE. Regardless of operating position and work loads, Timken bearings keep the spindle in positive alignment. Their tapered design lets them take *both* radial and thrust loads in any combination.

TAKE HEAVY LOADS, RESIST WEAR. Full line contact between rollers and races gives Timken bearings load-carrying capacity to spare. And both rollers and races are case-carburized to give them hard, wear-resistant surfaces over tough, shock-resistant cores. They last longer, reduce maintenance.

CUT MAINTENANCE COSTS. Timken bearings hold shafts concentric with their housings. Dirt stays out; lubricant stays in. They are geometrically designed to roll true, precision-made to make sure they do. We even make our own steel. No other American bearing manufacturer takes this extra step to insure the highest quality.

Whether you buy machines or build them, make sure you get the best bearings. Look for the trade-mark "TIMKEN". The Timken Roller Bearing Company, Canton 6, Ohio. Canadian plant: St. Thomas, Ontario. Cable address: "TIMROSCO".

This symbol on a product means its bearings are the best.

TIMKEN

TRADE-MARK REG. U. S. PAT. OFF.

TAPERED ROLLER BEARINGS ROLL THE LOAD